The Heating Ventilating Magazine

HEATING DATA

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THE HEATING AND VENTILATING MAGAZINE—1123 BROADWAY, N. Y. CITY

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on
Heating and Ventilation

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THE HEATING AND VENTILATING MAGAZINE — 1123 BROADWAY — N.Y. CITY.

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B. T. U. Losses for Various Types of Construction

In the computation of heating requirements for buildings the first requisite is to ascertain the maximum probable heat loss per hour under extreme weather conditions. To a great extent the finer graduations in such calculations may be safely avoided, but for those who may desire to be absolutely correct the following tables have been prepared giving the heat loss co-efficient for 1 sq. ft. per degree F. per hour and also the calculating factors for a temperature difference from 35° to 80° F. for each co-efficient. The figures given in the tables are based on the practice of the German government, the United States government, as well as on the practice of several well-known American Engineers.

In the modern building refinements of the wall factor are not usually of great moment, owing to the larger proportion of glass surface now being used and the relatively greater heat loss of the glass. Therefore, care in computing the window and door areas, the window factor, and the allowance for exposure and leakage are the more essential items.

It is often the case, however, where combinations of construction are encountered, either in materials or in the combined thicknesses, that even approximate factors are not available; in such cases the factor may be developed if the factor is known of each of the two materials in the thicknesses used. The combined resistance of the two is then the sum of the resistances of each and the resistance is the reciprocal of the transmission factor.

Thus, if 20-in. brick transmits 16 B.T.U. at 70° F. difference, its resistance is 1/16. And if 12-in. stone at 70° F. difference transmits 35 B.T.U., its resistance is 1/35. The two combined into a wall will have a combined resistance of 1/16 plus 1/35, or 51/560 and the transmission factor is the reciprocal of the resistance or 11 B.T.U. per hour.

With glass and skylight it is desirable to consider single thickness in all cases, owing to the fact that the single thickness may be substituted by the building contractor without the knowledge of the owner, or it may be substituted by the owner to save cost, or, even if double thick be installed at first, it may in time become broken and be replaced with single-thickness glass.

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HEAT LOSS CO-EFFICIENTS (CE).

(B.T.U. Loss per square foot, per degree F., per hour.)

Brick Wall Thickness in inches		Temperature Difference, Deg. F.									
	CE	35	40	45	50	55	60	65	70	75	80
Plain.											
4	0.68	23.8	27.2	30.6	34.0	37.4	40.8	44.2	47.6	51.0	54.4
8	0.40	14.0	16.0	18.0	20.0	22.0	24.0	26.0	28.0	30.0	32.0
12	0.31	10.8	12.4	13.9	15.5	17.0	18.6	20.1	21.7	23.2	24.8
16	0.26	9.1	10.4	11.7	13.0	14.3	15.6	16.9	18.2	19.5	20.8
20	0.23	8.0	9.2	10.3	11.5	12.6	13.8	14.9	16.1	17.2	18.4
24	0.20	7.0	8.0	9.0	10.0	11.0	12.0	13.0	14.0	15.0	16.0
28	0.18	6.3	7.2	8.1	9.0	9.9	10.8	11.7	12.6	13.5	14.4
32	0.16	5.6	6.4	7.2	8.0	8.8	9.6	10.4	11.2	12.0	12.8
36	0.12	4.2	4.8	5.4	6.0	6.6	7.2	7.8	8.4	9.0	9.6
Plastered Inside.											
4	0.70	24.5	28.0	31.5	35.0	38.5	42.0	45.5	49.0	52.5	56.0
8	0.42	14.7	16.8	18.9	21.0	23.1	25.2	27.3	29.4	31.5	33.6
12	0.33	11.5	13.2	14.8	16.5	18.1	19.8	21.4	23.1	24.7	26.4
16	0.25	8.7	10.0	11.2	12.5	13.7	15.0	16.2	17.5	18.7	20.0
20	0.23	8.0	9.2	10.3	11.5	12.6	13.8	14.9	16.1	17.2	18.4
24	0.21	7.3	8.4	9.4	10.5	11.5	12.6	13.6	14.7	15.7	16.8
28	0.19	6.6	7.6	8.5	9.5	10.4	11.4	12.3	13.3	14.2	15.2
32	0.17	5.9	6.8	7.6	8.5	9.3	10.2	11.0	11.9	12.7	13.6
36	0.13	4.5	5.2	5.8	7.1	7.8	8.4	9.1	9.7	10.5	11.2
One Side Furred and Plastered.											
4	0.56	19.6	22.4	25.2	28.0	30.8	33.6	36.4	39.2	42.0	44.8
8	0.30	10.5	12.0	13.5	15.0	16.5	18.0	19.5	21.0	22.5	24.0
12	0.23	8.0	9.2	10.3	11.5	12.6	13.8	14.9	16.1	17.2	18.4
16	0.20	7.0	8.0	9.0	10.0	11.0	12.0	13.0	14.0	15.0	16.0
20	0.18	6.3	7.2	8.1	9.0	9.9	10.8	11.7	12.6	13.5	14.4
24	0.16	5.6	6.4	7.2	8.0	8.8	9.6	10.4	11.2	12.0	12.8
28	0.14	4.9	5.6	6.3	7.0	7.7	8.4	9.1	9.8	10.5	11.2
32	0.12	4.2	4.8	5.4	6.0	6.6	7.2	7.8	8.4	9.0	9.6
Plastered Two Sides											
4	0.43	15.0	17.2	19.3	21.5	23.6	25.8	27.9	30.1	32.5	34.4
8	0.33	11.5	13.2	14.8	16.5	18.1	19.8	21.4	23.1	24.7	26.4
12	0.26	9.1	10.4	11.7	13.0	14.3	15.6	16.9	18.2	19.5	20.8

NOTE—For brick and sandstone see "Combinations" Sheet No. 1-C.

HEAT LOSS CO-EFFICIENTS (CE).

(B.T.U. Loss per square foot, per degree F., per hour.)

STONE WALL Thickness in Inches.		Temperature Difference, Deg. F.									
Limestone, Plain.	CE	35	40	45	50	55	60	65	70	75	80
12	0.49	17.1	19.6	22.0	24.5	26.9	29.4	31.8	34.3	36.7	39.2
16	0.46	16.1	18.4	20.7	23.0	25.3	27.6	29.9	32.2	34.5	36.8
20	0.41	14.3	16.4	18.4	20.5	22.5	24.6	26.6	28.7	30.7	32.8
24	0.37	12.9	14.8	16.6	18.5	20.3	22.2	24.0	25.9	27.7	29.6
28	0.33	11.5	13.2	14.8	16.5	18.1	19.8	21.4	23.1	24.7	26.4
32	0.29	10.1	11.6	13.0	14.5	15.9	17.4	18.8	20.3	21.7	23.2
Sand Stone, Plain.											
12	0.50	17.5	20.0	22.5	25.0	27.5	30.0	32.5	35.0	37.5	40.0
16	0.45	15.7	18.0	20.2	22.5	24.7	27.0	29.2	31.5	33.7	36.0
20	0.40	14.0	16.0	18.0	20.0	22.0	24.0	26.0	28.0	30.0	32.0
24	0.36	12.6	14.4	16.2	18.0	19.8	21.6	23.4	25.2	27.0	28.8
28	0.32	11.2	12.8	14.4	16.0	17.6	19.2	20.8	22.4	24.0	25.6
32	0.28	9.8	11.2	12.6	14.0	15.4	16.8	18.2	19.6	21.0	22.4

NOTE—Some authorities use losses for stone of 60% more than brick.

CONCRETE WALL Plain											
4	1.07	37.4	42.8	48.1	53.5	58.8	64.2	69.5	74.9	80.2	85.6
6	0.70	24.5	28.0	31.5	35.0	38.5	42.0	45.5	49.0	52.5	56.0
8	0.51	17.8	20.4	22.9	25.5	28.0	30.6	33.1	35.7	38.2	40.8
12	0.43	15.0	17.2	19.3	21.5	23.6	25.8	27.9	30.1	32.5	34.4
16	0.36	12.6	14.4	16.2	18.0	19.8	21.6	23.4	25.2	27.0	28.8

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HEAT LOSS CO-EFFICIENTS (CE).

(B.T.U. loss per square foot, per degree F., per hour.)

Concrete and Sandstone Wall Thickness in Inches. Plain.	CE	Temperature Difference, Deg. F. 35	40	45	50	55	60	65	70	75	80
12	0.45	15.7	18.0	20.2	22.5	24.7	27.0	29.2	31.5	33.7	36.0
16	0.39	13.6	15.6	17.5	19.5	21.4	23.4	25.3	27.3	29.2	31.2
20	0.35	12.2	14.0	15.7	17.5	19.2	21.0	22.7	24.5	26.2	28.0
24	0.31	10.8	12.4	13.9	15.5	17.0	18.6	20.1	21.7	23.2	24.8
28	0.28	9.8	11.2	12.6	14.0	15.4	16.8	18.2	19.6	21.0	22.4
32	0.26	9.1	10.4	11.7	13.0	14.3	15.6	16.9	18.2	19.5	20.8
Brick and Sandstone Wall											
4-in. Br. and 4-in. Ss.	0.31	10.8	12.4	13.9	15.5	17.0	18.6	20.1	21.7	23.2	24.8
4-in. Br. and 8-in, Ss.	0.29	10.1	11.6	13.0	14.5	15.9	17.4	18.8	20.3	21.7	23.2
4-in. Br. and 12-in. Ss.	0.26	9.1	10.4	11.7	13.0	14.3	15.6	16.9	18.2	19.5	20.8
8-in. Br. and 4-in. Ss.	0.22	7.7	8.8	9.9	11.0	12.1	13.2	14.3	15.4	16.5	17.6
8-in. Br. and 8-in. Ss.	0.20	7.0	8.0	9.0	10.0	11.0	12.0	13.0	14.0	15.0	16.0
8-in. Br. and 12-in. Ss.	0.19	6.6	7.6	8.5	9.5	10.4	11.4	12.3	13.3	14.2	15.2
12-in. Br. and 4-in. Ss.	0.17	5.9	6.8	7.6	8.5	9.3	10.2	11.0	11.9	12.7	13.6
12-in. Br. and 8-in. Ss.	0.16	5.6	6.4	7.2	8.0	8.8	9.6	10.4	11.2	12.0	12.8
12-in. Br. and 12-in. Ss.	0.15	5.2	6.0	6.7	7.5	8.2	9.0	9.7	10.5	11.2	12.0
16-in. Br. and 4-in. Ss.	0.21	7.3	8.4	9.4	10.5	11.5	12.6	13.6	14.7	15.7	16.8
16-in. Br. and 8-in. Ss.	0.20	7.0	8.0	9.0	10.0	11.0	12.0	13.0	14.0	15.0	16.0
16-in. Br. and 12-in. Ss.	0.19	6.6	7.6	8.5	9.5	10.4	11.4	12.3	13.3	14.2	15.2
20-in. Br. and 4-in. Ss.	0.20	7.0	8.0	9.0	10.0	11.0	12.0	13.0	14.0	15.0	16.0
20-in. Br. and 8-in. Ss.	0.19	6.6	7.6	8.5	9.5	10.4	11.4	12.3	13.3	14.2	15.2
20-in. Br. and 12-in. Ss.	0.17	5.9	6.8	7.6	8.5	9.3	10.2	11.0	11.9	12.7	13.6
24-in. Br. and 4-in. Ss.	0.17	5.9	6.8	7.6	8.5	9.3	10.2	11.0	11.9	12.7	13.6
24-in. Br. and 8-in. Ss.	0.16	5.6	6.4	7.2	8.0	8.8	9.6	10.4	11.2	12.0	12.8
24-in. Br. and 12-in. Ss.	0.14	4.9	5.6	6.3	7.0	7.7	8.4	9.1	9.8	10.5	11.2
28-in. Br. and 4-in. Ss.	0.16	5.6	6.4	7.2	8.0	8.8	9.6	10.4	11.2	12.0	12.8
28-in. Br. and 8-in. Ss.	0.14	4.9	5.6	6.3	7.0	7.7	8.4	9.1	9.8	10.5	11.2
28-in. Br. and 12-in. Ss.	0.13	4.5	5.2	5.8	6.5	7.1	7.8	8.4	9.1	9.7	10.4

HEAT LOSS CO-EFFICIENTS (CE).

(B.T.U. LOSS PER SQUARE FOOT, PER DEGREE F., PER HOUR).

Terra Cotta or Tile Walls

		Temperature Difference, Deg. F.									
Thickness in Inches. Tile, Plain.	CE	35	40	45	50	55	60	65	70	75	80
4	0.79	27.6	31.6	35.5	39.5	43.4	47.2	51.3	55.3	59.2	63.2
8	0.56	19.6	22.4	25.2	28.0	30.8	33.6	36.4	39.2	42.0	44.8
12	0.44	15.4	17.6	19.8	22.0	24.2	26.4	28.6	30.8	33.0	35.2
16	0.40	14.0	16.0	18.0	20.0	22.0	24.0	26.0	28.0	30.0	32.0
20	0.33	11.5	13.2	14.8	16.5	18.1	19.8	21.4	23.1	24.7	26.4
TILE AND STUCCO											
4	0.75	26.2	30.0	33.7	37.5	41.2	45.0	48.7	52.5	56.2	60.0
8	0.54	18.9	21.6	24.3	27.0	29.7	32.4	35.1	37.8	40.5	43.2
12	0.41	14.3	16.4	18.4	20.5	22.5	24.6	26.6	28.7	30.7	32.8
16	0.37	12.9	14.8	16.6	18.5	20.3	22.2	24.0	25.9	27.7	29.6
20	0.31	10.8	12.4	13.9	15.5	17.0	18.6	20.1	21.7	23.2	24.8
TILE, STUCCO AND PLASTER											
4	0.34	11.9	13.6	15.3	17.0	18.7	20.4	22.1	23.8	25.5	27.2
8	0.27	9.4	10.8	12.1	13.5	14.8	16.2	17.5	18.9	20.2	21.6
12	0.26	9.1	10.4	11.7	13.0	14.3	15.6	16.9	18.2	19.5	20.8
16	0.23	8.0	9.2	10.3	11.5	12.6	13.8	14.9	16.1	17.2	18.4
20	0.20	7.0	8.0	9.0	10.0	11.0	12.0	13.0	14.0	15.0	16.0

HEAT LOSS CO-EFFICIENTS (CE).

(B.T.U. Loss per square foot, per degree F., per hour.)

FRAME WALLS OF—	CE	Temperature Difference, Deg. F.									
		35	40	45	50	55	60	65	70	75	80
Studs covered as follows:											
1 side L. & P.	0.60	21.0	24.0	27.0	30.0	33.0	36.0	39.0	42.0	45.0	48.0
2 sides L. & P.	0.34	11.9	13.6	15.3	17.0	18.7	20.4	22.1	23.8	25.5	27.2
1 side Clapboards	0.47	16.4	18.8	21.1	23.5	25.8	28.2	30.5	32.9	35.2	37.6
1 side Clapboards and 1 L. & P.	0.44	15.4	17.6	19.8	22.0	24.2	26.4	28.6	30.8	33.0	35.2
1 side Paper and Clapboards	0.34	11.9	13.6	15.3	17.0	18.7	20.4	22.1	23.8	25.5	27.2
1 side Paper and Clapboards and 1 L. and P.	0.31	10.8	12.4	13.9	15.5	17.0	18.6	20.1	21.7	23.2	24.8
1 side Clapboards and Sheathing	0.30	10.5	12.0	13.5	15.0	16.5	18.0	19.5	21.0	22.5	24.0
1 side Clapboards and Sheathing and 1 L. and P	0.27	9.4	10.8	12.1	13.5	14.8	16.2	17.5	18.9	20.2	21.6
1 side Clapboards and Sheathing and Paper	0.26	9.1	10.4	11.7	13.0	14.3	15.6	16.9	18.2	19.5	20.8
1 side as above and 1 side L. and P.	0.23	8.0	9.2	10.3	11.5	12.6	13.8	14.9	16.1	17.2	18.4
Clapboards Brick Lined and P.	0.22	7.7	8.8	9.9	11.0	12.1	13.2	14.3	15.4	16.5	17.6

NOTE—L indicates lath and P, plaster.

HEAT LOSS CO-EFFICIENTS (CE).

(B.T.U. Loss per square foot, per degree F., per hour.)

GLASS

		Temperature Difference, Deg. F.									
	CE	35	40	45	50	55	60	65	70	75	80
Windows—Single-Thick	1.00	35.0	40.0	45.0	50.0	55.0	60.0	65.0	70.0	75.0	80.0
Windows—Double-Thick	0.62	21.7	24.8	27.9	31.0	34.1	37.2	40.3	43.4	46.5	49.6
Windows—Double	0.56	19.6	22.4	25.2	28.0	30.8	33.6	36.4	39.2	42.0	44.8
Skylight—Single	1.16	40.6	46.4	52.2	58.0	63.8	69.6	75.4	81.2	87.0	92.8
Skylight—Double	0.48	16.8	19.2	21.6	24.0	26.4	28.8	31.2	33.6	36.0	38.4

Doors Same as single-thickness glass.

PARTITIONS

Wire Lath and Cement Plaster 1½ in.-2½ in. thick	0.61	21.3	24.4	27.4	30.5	33.5	36.6	39.6	42.7	45.7	48.8
Ditto, 3 in.-3½ in. thick	0.49	17.1	19.6	22.0	24.5	26.9	29.4	31.8	34.3	36.7	39.2
Corrugated Iron, Unlined	0.84	29.4	33.6	37.8	42.0	46.2	50.4	54.6	58.8	63.0	67.2

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HEAT LOSS CO-EFFICIENTS (CE).

(B.T.U. loss per square foot, per degree F., per hour.)

		Temperature Difference, Deg. F.									
CEILINGS	CE	35	40	45	50	55	60	65	70	75	80
Lath and Plaster only	0.62	21.7	24.8	27.9	31.0	34.1	37.2	40.3	43.4	46.5	49.6
Fire proof floor as ceiling	0.20	7.0	8.0	9.0	10.0	11.0	12.0	13.0	14.0	15.0	16.0
Also see "Floors"											
FLOORS											
Dirt	0.23	8.0	9.2	10.3	11.5	12.6	13.8	14.9	16.1	17.2	18.4
Wood on ground	0.10	3.5	4.0	4.5	5.0	5.5	6.0	6.5	7.0	7.5	8.0
Wood on concrete	0.10	3.5	4.0	4.5	5.0	5.5	6.0	6.5	7.0	7.5	8.0
Cement on Tile	0.30	10.5	12.0	13.5	15.0	16.5	18.0	19.5	21.0	22.5	24.0
Single Wood on Joists	0.45	15.7	18.0	20.2	22.5	24.7	27.0	29.2	31.5	33.7	36.0
Double Wood on Joists	0.31	10.8	12.4	13.9	15.5	17.0	18.6	20.1	21.7	23.2	24.8
Single Wood L. and P on Joists	0.26	9.1	10.4	11.7	13.0	14.3	15.6	16.9	18.2	19.5	20.8
Double Wood L. and P. on Joists	0.18	6.3	7.2	8.1	9.0	9.9	10.8	11.7	12.6	13.5	14.4
Concrete on Brick Arch	0.20	7.0	8.0	9.0	10.0	11.0	12.0	13.0	14.0	15.0	16.0
Wood on Brick Arch	0.15	5.2	6.0	6.7	7.5	8.2	9.0	9.7	10.5	11.2	12.0
Dbl. Wood on Brick Arch	0.10	3.5	4.0	4.5	5.0	5.5	6.0	6.5	7.0	7.5	8.0
ROOFS											
Unlined Slate	0.80	28.0	32.0	36.0	40.0	44.0	48.0	52.0	56.0	60.0	64.0
Slate on T. and G. Boards	0.30	10.5	12.0	13.5	15.0	16.5	18.0	19.5	21.0	22.5	24.0
Iron on T. and G. Boards	0.17	5.9	6.8	7.6	8.5	9.3	10.2	11.0	11.9	12.7	13.6
Unlined Metal Roof	1.30	45.5	52.0	58.5	65.0	71.5	78.0	84.5	91.0	97.5	104.0
Patent Tar and Gravel on Tar and Gravel Bed	0.30	10.5	12.0	13.5	15.0	16.5	18.0	19.5	21.0	22.5	24.0
Tiling 1 in. thick	0.80	28.0	32.0	36.0	40.0	44.0	48.0	52.0	56.0	60.0	64.0
6-in. Tile, 2-in. Concrete and Tar and Gravel Roofing	0.36	12.6	14.4	16.2	18.0	19.8	21.6	23.4	25.2	27.0	28.8
8-in. tile, 1-in. Concrete and Tar and Gravel Roofing	0.40	14.0	16.0	18.0	20.0	22.0	24.0	26.0	28.0	30.0	32.0
4-in. Concrete, Cinder Fill and Tar and Gravel Roofing	0.60	21.0	24.0	27.0	30.0	33.0	36.0	39.0	42.0	45.0	48.0
6-in. Concrete, Cinder Fill & Tar & Gravel Roofing	0.54	18.9	21.6	24.3	27.0	29.7	32.4	35.1	37.8	40.5	43.2

B. T. U.—CEILING, FLOOR AND ROOF | **NO. 1—C**

HEAT LOSS TABLES.

Index of Authorities Quoted.

A—Average of various authorities used by the Department of Buildings and Grounds, University of Pennsylvania.

B—Alfred R. Wolff. Translation of requirements of the German Government—*Journal* of the Franklin Institute, Vol. 138, July, 1894, p. 45. Also Transactions American Society Heating and Ventilating Engineers, Vol. 3, 1897, p. 21.

C—Recknagel and Reitschel. Values interpolated by Kinealy. See "Formulas and Tables for Heating," 1899, p. 35. See also THE HEATING AND VENTILATING MAGAZINE, July, 1915, p. 21.

D—J. H. Kinealy. Construction used in this country but not in Germany. "Formulas and Tables for Heating," 1899, p. 35.

E—R. C. Carpenter. Translation from Péclet, "Heating and Ventilation of Buildings," 1911 (fifth edition).

F—B. F. Sturtevant Co. Based on Wolff's figures. Catalogues No. 84 and No. 215, "Heating and Ventilation." (Slight variation from Wolff's figures).

G—Austrian government. Translated by W. W. Macon (Trans. A. S. H. V. E., Vol. 14, 1908, p. 37). Also THE HEATING AND VENTILATING MAGAZINE, February, 1908 and July, 1915.

H—Nelson S. Thompson—"Mechanical Equipment of Federal Buildings," 1915.
  H-a—Federal buildings based upon figures of Professor S. Homer Woodbridge.
  H-b—Factories or other buildings of inferior construction.

I—A. M. Greene, Jr., "The Elements of Heating and Ventilation," 1913.

J—Buffalo Forge Co., "Fan Engineering," 1914. Also Catalogue No. 197, 1908.

K—William G. Snow, "The Principles of Heating," 1912. Calculated from data published by Kinealy in "German Formulas and Tables for Heating and Ventilating Work," (Given for a 70° F. difference and when reduced to 1° F. difference do not check with other authorities.

L—Charles L. Hubbard, "Power—Heating and Ventilation," Vol. 2, 1914. Values given are for most thorough construction.
  For ordinary well-built house, add 20%.
  For fairly good construction, add 20%.
  For poor construction, add 30%.

M—J. M. Harrison, "Applied Heating and Ventilation," 1911.

N—John R. Allen, "Notes on Heating and Ventilating," 1905. These values are based on those of the German government.

O—James D. Hoffman, "Handbook for Heating and Ventilating Engineers," 1913.

P—Louis A. Harding, "Mechanical Equipment of Buildings," Vol. 1, 1916, "Heating and Ventilation," p. 59. Also "Design of Blower Heating Systems for Factory and Shop Buildings," 1915. Also "Heat Losses by Transmission Through Various Building Materials," (Trans. A. S. H. V. E. Vol. 19, 1913, p. 209.)

Q—Carlton F. Tweed, THE HEATING AND VENTILATING MAGAZINE, July, 1915. Also Power Plant Library.

R—National District Heating Association. Compiled by Professor C. B. Veal, *Bulletin* N. D. H. A., Jan. 15, 1916

S—Practical Engineer.

T—American Radiator Co., *Ideal Fitter,* May, 1916, p. 268.

U—Frank L. Busey, "Transmission of Heat Through Building Materials," *Power,* April 21, 1914, p. 574.

V—Prussian government requirements. Translated by Kinealy from Recknagel's "Kalender für Gesundheit Teckniker" for 1897, "Tables and Formulas for Heating."

UNIVERSITY OF ILLINOIS

HEAT LOSS TABLES.

Index of Authorities Quoted.

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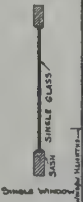
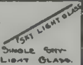
W—The Heating and Ventilating Magazine, "Standard Heating Data Sheets," February and March, 1917.

X—James A. Donnelly, "The Establishment of Standard Methods of Proportioning Direct Radiation and Standard Sizes of Steam and Return Mains." (Trans. A. S. H. V. E., Vol. 21, p. 529).

Y—Charles F. Hauss, Antwerp, Belgium. To figure heating work accurately. Constants obtained from practice of German engineer, Adolph Block, of Hamburg. (Trans. A. S. H. V. E., Vol. 10, 1904, p. 114.)

Z—E. N. Irwin, "Elements of Heating," *Power*, Jan. 20, 1914, p. 89.

1390-4

GLASS	Thickness	A Used by U. of Pa.	B German Gov (A.R. Wolff)	C Recknagel & Reitschel	E Peclet (Carpenter)	F B F Sturtevant Cats 84 & 215	G Austrian Gov (Macon)	Y Hauss Ger Practice	P Harding	Thompson I: Federal Bldgs a	Thompson I: Factory Bldgs b	1 Greene 1913	J Buffalo Forge Co	K Snow	L Hubbard	M Harrison	N Allen	O Hoffman	Q Tweed	R Nat Dist Heat. Asso	S Practical Eng	T American Rad. Co		V Prussian Gov (Recknagel)	W H&V Magazine 1917—	X Donnelly	Z Irwin	
	STD	1.09	1776	1.09		1215	1.08	1.00	1.126	1.00	1.20	.96	1.09	1.10	1.20	1.25	.776	1.0	1.05		1.2	1.09		1.03	1.00	1.00	1.10	
	Tight	1.07	Above constant taken from Wolffs original article. Later reprints give it as 1.09				1.07					⅛ inch								1.07								
	Weather stripped	.90					10'-1'					Thick								.90								
	Medium	1.20					Thickness of Glass													1.20								
	Loose	1.35																		1.35								
	Window Heights 3'-3½"				.980																							
	6'-7"				.945																							
	10'-0"				.930																							
	13'-3"				.920																							
Single Window	16'-3"				.910																							
	Plate	.74																		.74								
		AA	BB	CC		FF	GG	YY	PP	HHa	HHb	II	JJ	KK	LL	MM	NN	OO	QQ	RR	SS	TT		VV	WW	XX	ZZ	
	STD	.62	.518	.46		.572	.47	.46	.45	.50	.56	.41	.46	.457	.60	.62	.518	.6	.5	.52	.6	.560		.472	.56	.571	.572	
									Triple Sash			⅛ inch																
Double Window									.281			Thick																
		AAA	BBB	CCC		FFF	GGG	YYY	PPP	HHHa	HHHb	III	JJJ	KKK	LLL	MMM	NNN	OOO	QQQ	RRR	SSS	TTT		VVV	WWW	XXX	ZZZ	
	STD	1.16	1.118	1.16		1.03	1.14	1.06		1.50	1.50	1.06	1.16	1.157	1.30		1.118	1.1	1.1	1.12	1.2	1.118		1.09	1.16	1.00	1.03	
Single Sky-Light Glass												¼ Thick																
		AAAA	BBBB	CCCC		FFFF	GGGG	YYYY	PPPP	HHHHa	HHHHb	IIII	JJJJ	KKKK	LLLL	MMMM	NNNN	OOOO	QQQQ	RRRR	SSSS	TTTT		VVVV	WWWW	XXXX	ZZZZ	
Double Skylight Glass	STD	.62	.62■	.48		.621	.48	.48	.49	.50	.62	.51	.48	[illegible]	.65		.621	.7	.6	.57	.65	.621		.492	0.48	.571	.621	
												¼" Thick																

H, HH, HHH, HHHH(a)—Opening in brick work measured as total glass surface

U, UU, UUU — Average of values for various temperature differences

■ —For multiple glass above constants are to be multiplied as follows:
Double by $\frac{4}{5}$
Triple by $\frac{2}{3}$
Quadruple by $\frac{3}{5}$
N layers by $\frac{2}{1+N}$

W—THE HEATING AND VENTILATING MAGAZINE, "Standard Heating Data Sheets," February and March, 1917.
X—James A. Donnelly, "The Establishment of Standard Methods of Proportioning Direct Radiation and Standard Sizes of Steam and Return Mains." (Trans. A. S. H. V. E., Vol. 21, p. 529).
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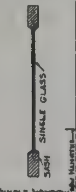
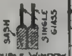
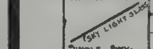
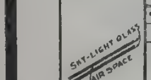
1390-4

GLASS	THICKNESS	A Used by U. of Pa.	B German Gov. (A. R. Wolff)	C Recknagel & Reitschel	E Peclet (Carpenter)	F B F Sturtevant Cat's 84&215	G Austrian Gov. (Macon)	Y Hauss Ger. Practice	P Harding	H Thompson Federal Bldgs. a	H Thompson Factory Bldgs. b	I Greene 1919	J Buffalo Forge Co.	K Snow	L Hubbard	M Harrison	N Allen	O Hoffman	Q Tweed	R Nat. Dist. Heat. Asso.	S Practical Eng.	T American Rad. Co.		V Prussian Gov. (Recknagel)	W H&V Magazine 1917—	X Donnelly	Z Irwin	
 Single glass Sash Single Window	STD.	1.09	1776	1.09		1215	1.06	1.00	1.126	1.00	1.20	.96	1.09	1.10	1.20	1.25	.776	1.0	1.05		1.2	1.09		1.03	1.00	1.00	1.10	
	Tight	1.07	Above constant taken from Wolff's original article. Later reprints give it as 1.09				1.07					1/8 inch								1.07								
	Weather stripped	.90										THICK								.90								
	Medium	1.20					Thickness of glass													1.20								
	Loose	1.35																		1.35								
Window Numbers	3'3"				.980																							
	6'7"				.945																							
	10'0"				.930																							
	13'3"				.920																							
	16'3"				.910																							
	Plate	.74																		.74								
 Sash Single glass Double Window		AA	BB	CC		FF	GG	YY	PP	HHa	HHb	II	JJ	KK	LL	MM	NN	OO	QQ	RR	SS	TT		VV	WW	XX	ZZ	
	STD.	.62	.518	.46		.572	.47	.46	.45	.50	.56	.41	.46	.457	.60	.62	.518	.6	.5	.52	.6	.560		.472	.56	.571	.572	
									Triple Sash			1/8 inch																
									.281			THICK																
 Sky light glass Single Sky-Light Glass.		AAA	BBB	CCC		FFF	GGG	YYY	PPP	HHHa	HHHb	III	JJJ	KKK	LLL	MMM	NNN	OOO	QQQ	RRR	SSS	TTT		VVV	WWW	XXX	ZZZ	
	STD.	1.16	1.118	1.16		1.03	1.14	1.06		1.50	1.50	1.06	1.16	1.157	1.30		1.118	1.1	1.1	1.12	1.2	1.118		1.09	1.16	1.00	1.03	
												THICK																
 Sky-light glass Air space Double Sky-Light Glass		AAAA	BBBB	CCCC		FFFF	GGGG	YYYY	PPPP	HHHH	HHHH	IIII	JJJJ	[illegible]	LLLL	MMMM	NNNN	OOOO	QQQQ	RRRR	SSSS	TTTT		VVVV	WWWW	XXXX	ZZZZ	
	STD.	.62	.621	.48		.621	.48	.48	.49	.50	.62	.51	.48	[illegible]	.65		.621	.7	.6	.57	.65	.621		.492	0.48	.571	.621	
												THICK																

H, HH, HHH, HHHH(a)—Opening in brick work measured as total glass surface.

U, UU, UUU — Average of values for various temperature differences.

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Double by $\frac{2}{3}$
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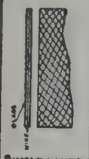
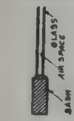
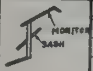
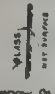
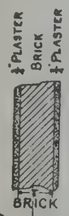
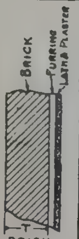
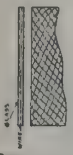
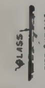
Quadruple by $\frac{2}{5}$
N layers by $\frac{2}{1+N}$

GLASS	THICKNESS	A USED AT U. OF PA.	C RECKNAGEL & REITSCHEL	G AUSTRIAN GOV. (MACON)	IRWIN	Z THOMPSON	K SNOW	Q TWEED	R NAT. DIST. HEAT. ASSO.	T AMERICAN RAD. CO.	I GREENE 1913	W H.&V. MAGAZINE 1917
 SINGLE WINDOW WIRE GLASS		1.09		1.04	1.0			1.35				
 SINGLE WINDOW DOUBLE GLASS			CC				KK					WW
		.62	.62				.614					.62
 SINGLE MONITOR GLASS						HHH			RRR	TTT		
	STD.	1.30				1.40 ×1.35			1.10	.950		
 WINDOW GLASS WET											IIII	
		1.10									1.1 ⅛" THICK	

HHH a FEDERAL BLDG.
HHH b FACTORY
× OPENING IN BRICK WORK MEASURED AS TOTAL GLASS SURFACE
RRR VOL. NO. 2 JAN. 15, 1916

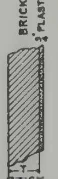
WALLS	THICKNESS T	A USED BY U. OF P	B GERMAN GOV (WOLFF)	C RECKNAGEL REITSCHEL	D KINEALY	F HUBBARD	G AUSTRIAN GOV (MACON)	I GREENE (1913)	J BUFFALO FORGE CO.	O HOFFMAN	P HARDING	Q TWEED	R NAT. DIST. HEAT ASSO	Ha THOMPSON ONE WALL EXP.	Hb THOMPSON TWO WALLS EXP.	W H&V MAGAZINE 1917	X DONNELLY	U BUSEY
 BRICK PLASTERED BOTH SIDES	4"	.43		.43												.43		
	8"	.35		.33			.40									.33		
	12"	.28		.26			.31									.26		
	16"	.24					.26											
	20"	.21					.22											
	24"	.18					.19											
	28"	.17					.17											
	32"	.15					.15											
	36"	.13					.14											
	40"	.13					.13											
 BRICK FURRING, LATH AND PLASTER ONE SIDE		AA	BB	CC	DD	LL	GG	II	JJ	OO	PP	QQ	RR	HH	HH	WW	XX	UU
	4"	.33		.29	.28			.28	.28			.28	.29			.56		
	8"	.27		.24	.23	.32		.24	.23	.280	.217	.24	.27			.30	.414	.23
	12"	.23		.21	.20	.26		.20	.20	.217	.185	.20	.24	.265	.232	.23	.300	.20
	16"	.21		.20	.18	.21		.18	.18	.182	.196	.18	.21			.20		.18
	18"	.20		IN PLACE OF FURRING GERMAN PRAC. USE PLASTER BOARD 1½" THICK WITH AIR SPACE. IT IS MADE OF MORTAR AND PLASTER OF PARIS										.210	.205		.228	
	20"	.19			.16	.18		.16	.16	.161		.16	.18			.18		
	21"	.18												.187	.185		.200	.16
	24"	.16				.16		.14		.147	.132	.14		.167	.150	.16		
	27"	.15												.152	.140		.157	
	28"	.15				.14		.13		.133		.13				.14		
	30"	.14				GIVEN AT 80% OF PLAIN BRICK								.140	.130		BASED ON TESTS BY HARDING	
	32"	.13						.12		.119		.12				.12		
	33"	.13												.130	.120			
	36"	.12						—		.7 OF NON-FURRED WALL				.120	.113			
	40"	.11												.112	.103			

B. T. U. LOSSES—Jones Tables (Continued).

GLASS	THICKNESS	A USED AT U. OF PA.	C RECKNAGEL & REITSCHEL	G AUSTRIAN GOV (MACON)	IRWIN	I THOMPSON	K SNOW	Q TWEED	R NAT. DIST. HEAT. ASSO.	T AMERICAN RAD. CO.	I GREENE 1913	W H.&V. MAGAZINE 1917—						
 SINGLE WINDOW WIRE GLASS		1.09		1.04	1.0			1.35										
SINGLE WINDOW DOUBLE GLASS			CC				KK					WW						
		.62	.62				.614					.62						
SINGLE MONITOR GLASS						HHH			RRR	TTT								
	STD.	1.30				1.40 *1.35			1.10	.950								
 WINDOW GLASS WET											IIII							
		1.10									1.1 ¼" THICK							

HHHa FEDERAL BLDGS
HHHb-FACTORY
* OPENING IN BRICK WORK MEASURED AS TOTAL GLASS SURFACE
RRR VOL. NO. 2 JAN. 15, 1916

WALLS	THICKNESS T	A USED BY U. OF P	B GERMAN GOV (WOLFF)	C RECKNAGEL REITSCHEL	D KINEALY	F HUBBARD	G AUSTRIAN GOV (MACON)	I GREENE (1913)	J BUFFALO FORGE CO	O HOFFMAN	P HARDING	Q TWEED	R NAT. DIST. HEAT ASSO	Ho THOMPSON ONE WALL EXP.	Ho THOMPSON TWO WALLS EXP.	W H&V MAGAZINE 1917—	X DONNELLY	U BUSEY
½" PLASTER BRICK ½" PLASTER BRICK PLASTERED BOTH SIDES	4"	.43		.43												.43		
	8"	.35		.33			.40									.33		
	12"	.28		.26			.31									.26		
	16"	.24					.26											
	20"	.21					.22											
	24"	.18					.19											
	28"	.17					.17											
	32"	.15					.15											
	36"	.13					.14											
	40"	.13					.13											
BRICK FURRING, LATH AND PLASTER ONE SIDE		AA	BB	CC	DD	LL	GG	II	JJ	OO	PP	QQ	RR	HH	HH	WW	XX	UU
	4"	.33		.29	.28			.28	.28			.28	.29			.56		
	8"	.27		.24	.23	.32		.24	.23	.280	.217	.24	.27			.30	.414	.23
	12"	.23		.21	.20	.26		.20	.20	.217	.185	.20	.24	.265	.232	.23	.300	.20
	16"	.21		.20	.18	.21		.18	.18	.182	.196	.18	.21			.20		.18
	18"	.20		IN PLACE OF FURRING GERMAN PRAC. USES PLASTERBOARD 1.18" THICK WITH AIR SPACE. IT IS MADE OF MORTAR AND PLASTER OF PARIS										.210	.205		.228	
	20"	.19			.16	.18		.16	.16	.161		.16	.18			.18		
	21"	.18												.187	.185		.200	.16
	24"	.16				.16		.14		.147	.132	.14		.167	.150	.16		
	27"	.15												.152	.140		.157	
	28"	.15				.14		.13		.133		.13				.14	BASED ON TESTS BY HARDING	
	30"	.14				GIVEN AS 80% OF PLAIN BRICK								.140	.130			
	32"	.13						.12		.119		.12				.12		
	33"	.13								.7 OF NON-FURRED WALL				.130	.120			
	36"	.12												.120	.113			
	40"	.11												.112	.103			

WALLS	THICKNESS T	USED BY U OF P	GERMAN GOV A.R. WOLFF	RECKNAGEL & RIETSCHEL	PRUSSIAN GOV RECKNAGEL	PECLET CARPENTER	B.F. STURTEVANT CATS 84 & 215 (A.R. WOLFF)	AUSTRIAN GOV (MACON)	HAUSS GEN. PRACTICE	GREENE	BUFFALO FORGE CO.	SNOW	HUBBARD	HARRISON	ALLEN	HOFFMAN	HARDING	TWEED	NAT. DIST. HEAT ASSO	PRACTICAL ENGINEERING	AMERICAN RAD CO.		DONNELLY	H & V MAGAZINE 1917	THOMPSON 1 WALL EXPOSED Ha	THOMPSON 2 WALLS EXPOSED Hb	THOMPSON Hc	IRWIN	BUSEY	SPANGLER
BRICK	4"	.60	.680	.520	.492	.430	[illegible]	—	.48	.550	.520	—	—	660	680	—	--	.550	.520	700	.680	—	—	.68	—	—	.680	.654	—	
	8"	.42	460	.370	.348	.370	.458	—	.34	.390	.370	.343	.400	.460	.460	.400	.363	.390	.400	.500	.460	—	.585	.40	—	—	.460	.458	.37.	
	12"	.32	320	.290	—	.320	.315	—	—	.310	.290	.300	.320	.300	.320	.310	.281	.310	.300	.400	.330	—	.386	.31	.318	.278	.330	.315	.29	
	16"	.26	260	.250	.266	.280	258	—	.26	.250	.250	.257	.260	.260	.260	.260	—	.250	.250	.300	.270	—	.285	.26	.252	.246	.270	.258	.25	
	20"	.23	230	.220	.226	.250	228	—	.22	.210	.220	.228	.220	.230	.230	.230	.220	.210	.220	.250	.230	—	.228	.23	.224	.222	.230	.228	.22	
	24"	.20	200	.190	.184	.240	.194	—	.18	.180	.190	.200	.200	.190	—	.210	.174	.180	—	.200	.200	—	—	.20	.200	.180	.200	.194	—	
	28"	.18	.174	.160	—	.220	.165	—	—	.160	—	—	.180	—	—	.190	—	.160	—	.150	.180	—	.186	.18	.182	.168	.180	GIVEN AS SOLID BRICK	—	
	30"	.17	—	—	.164	—	—	—	.16	—	—	.171	—	.160	—	—		—	—	—	—	—	—	—	.168	.156	—			
	32"	.16	150	.140	—	.210	.143	—	—	.150	—	—	—	—	—	.170		.150	—	—	.160	—		.16	.156	.144	.160			
	36"	.14	129	.120	.133	.200	.129	—	.13	—	—	.143	—	.130	—	—		—	—	—	.150	—		.12	.144	.136	.150			
	40"	.13	115	BRICKS [illegible] VERT JOINTS	.123	.180	.114	—	.12	—	—	—	—	—	—	—		—	—	—	—	—		—	.134	.124	.130			
	46"	.11	—		.113	—	—	—	.11	—	—	—	—	—	—	—		—	—	—	—	—			—	—	—			
	18"	.25			—	.260			—																					
		AA	BB	CC		EE	FF	GG		II	JJ	KK	LL	MM	NN	OO		QQ	RR	SS	TT		XX	WW	HHa	HHb			UU	
 BRICK ¾" PLASTER	4"	.49	—	.490	—	—	—	—	—	.510	.500	—	—	—	—	—	—	—	.490	—	—	—	—	.70	—	—	—	—	—	
	8"	.38	—	.360	—	—	—	.43	—	.370	.360	—	—	—	—	—	—	—	.380	—	—	—	.500	.42	—	—	—	—	.36	.35
	12"	.29	—	.280	—	—	—	.34	—	.290	.280	—	—	—	—	—	—	—	.290	—	—	—	.342	.33	.305	.267	—	—	.28	.28
	16"	.25	—	.240	—	—	—	.29	—	.240	.240	—	—	—	—	—	—	—	.240	—	—	—	.257	.25	.242	.236	—	—	.24	.24
	20"	.22	—	.210	—	—	—	.24	—	.210	.210	—	—	—	—	—	—	—	.210	—	—	—	.214	.23	.215	.213	—	—	.21	.23
	24"	.19	—	.180	—	—	—	.21	—	.180	.180	—	—	—	—	—	—	—	—	—	—	—	—	.21	.192	.173	—	—	—	.18
	28"	.17	—	.160	—	—	—	.18	—	.160	—	—	—	—	—	—	—	—	—	—	—	—	.171	.19	.175	.161	—	—	—	.16
	32"	.15	—	.140	—	—	—	.16	—	.140	—	—	—	—	—	—	—	—	—	—	—	—	BASED ON TESTS BY HARDING	.17	.150	.138	—	—		.13
	36"	.13	—	.120	—	—	—	.14	—	—	—	—	—	—	—	—	—	—	—	—	—	—		.13	.138	.130	—	—		
	40"	.13	—	—	—	—	—	.13	—	—	—	—	—	—	—	—	—	—	—	—	—	—		—	.129	.119	—	—		
																									—	—				
BRICK PLASTERED ONE SIDE	30"	.16																							.161	.150				
																									—	—				.33

E- SEE STONE WALL.

V- {UPPER FIGURES ARE, EQUIVALENT OF SIZES IN METRIC SYSTEM

O SEE BRICK WALL, FURRING, LATH AND PLASTER

U- AVERAGE OF VALUES FOR VARIOUS TEMPERATURE DIFFERENCES.

SEE STONE WALL

THE LIBRARY
OF THE
UNIVERSITY OF ILLINOIS

WALLS	Thickness T	Used by U of P. A	German Gov. (A.R. Wolff) B	Recknagel & Rietschel C	Prussian Gov. Recknagel D	Peclet Carpenter E	B.F. Sturtevant Cat. 846215 (A.R. Wolff) F	Austrian Gov. (Macon) G	Hauss Ges. Practice H	Greene I	Buffalo Forge Co. J	Snow K	Hubbard L	Harrison M	Allen N	Hoffman O	Harding P	Tweed Q	Nat. Dist. Heat Asso. R	Practical Engineering S	American Rad Co. T		Donnelly X	H & V Magazine 1917 W	Thompson 1 Wall exposed Ha	Thompson 2 Walls exposed Ha	Thompson Factory Bldgs. Hb	Irwin Z	Busey U	Spangler
BRICK	4"	.60	680	.520	.432	.430	658	—	.48	.550	.520	—	—	660	680	—	—	.550	.520	700	.680	—	—	.68	—	—	.680	.654	—	
	8"	.42	460	.370	.348	.370	.453	—	.34	.390	.370	.343	.400	.460	.460	.400	.363	.390	.400	.500	.460	—	.555	.40	—	—	.460	.458	.37	
	12"	.32	320	.290	—	.320	.315	—	—	.310	.290	.300	.320	.300	.320	.310	.281	.310	.300	.400	.330	—	.386	.31	.318	.278	.330	.315	.29	
	16"	.26	.260	.250	.266	.280	258	—	.26	.250	.250	.257	.260	.260	.260	.260	—	.250	.250	.300	.270	—	.233	.26	.242	.243	.270	.258	.25	
	20"	.23	230	.220	.226	.250	228	—	.22	.210	.220	.225	.220	.230	.230	.230	.220	.210	.220	.250	.230	—	.228	.23	.274	.222	.230	.228	.22	
	24"	.20	200	.190	.194	.240	.194	—	.18	.180	.190	.200	.200	.190	—	.210	.174	.180	—	.200	.200	—	—	.20	.200	.190	.200	.194	—	
	28"	.18	.174	.160	—	.220	.165	—	—	.160	—	—	.180	—	—	.190	—	.160	—	.150	.180	—	.166	.18	.182	.168	.180	[illegible] Solid Brick	—	
	30"	.17	—	—	.164	—	—	—	.16	—	—	.171	—	.160	—	—		—	—	—	—	—	—	—	.164	.158	—			
	32"	.16	150	.140	—	.210	.143	—	—	.150	—	—	—	—	—	.170		.150	—	—	.160	—		.16	.15	.144	.160			
	36"	.14	129	.120	.133	.200	.129	—	.13	—	—	.143	—	.130	—	—		—	—	—	.150	—		.12	.144	.136	.150			
	40"	.13	115	[illegible]	.123	.180	.114	—	.12	—	—	—	—	—	—	—		—	—	—	—	—		—	.134	.124	.130			
	46"	.11	—		.113	—	—	—	.11	—	—	—	—	—	—	—		—	—	—	—	—			—	—	—			
	18"	.25			—	.260			—																					
		AA	BB	CC		EE	FF	GG		II	JJ	KK	LL	MM	NN	OO		QQ	RR	SS	TT		XX	WW	HH1	HH2			UU	
BRICK 1" PLASTER	4"	.49	—	.490	—	—	—	—	—	.510	.500	—	—	—	—	—	—	—	.490	—	—	—	—	.70	—	—	—	—	—	
	8"	.38	—	.360	—	—	—	.43	—	.370	.360	—	—	—	—	—	—	—	.380	—	—	—	.500	.42	—	—	—	—	.36	.35
	12"	.29	—	.280	—	—	—	.34	—	.290	.280	—	—	—	—	—	—	—	.290	—	—	—	.347	.33	.305	.267	—	—	.28	.28
	16"	.25	—	.240	—	—	—	.29	—	.240	.240	—	—	—	—	—	—	—	.240	—	—	—	.257	.25	.242	.236	—	—	.24	.24
	20"	.22	—	.210	—	—	—	.24	—	.210	.210	—	—	—	—	—	—	—	.210	—	—	—	.214	.23	.215	.213	—	—	.21	.23
	24"	.19	—	.180	—	—	—	.21	—	.180	.180	—	—	—	—	—	—	—	—	—	—	—	—	.21	.192	.173	—	—	—	.18
	28"	.17	—	.160	—	—	—	.18	—	.160	—	—	—	—	—	—	—	—	—	—	—	—	.171	.19	.175	.161	—	—	—	.16
	32"	.15	—	.140	—	—	—	.16	—	.140	—	—	—	—	—	—	—	—	—	—	—	—	Based on tests by Harding	.17	.150	.138	—	—		.13
	36"	.13	—	.120	—	—	—	.14	—	—	—	—	—	—	—	—	—	—	—	—	—	—		.13	.139	.130	—	—		
	40"	.13	—	—	—	—	—	.13	—	—	—	—	—	—	—	—	—	—	—	—	—	—		—	.129	.119	—	—		
																									—	—				
BRICK PLASTERED ONE SIDE	30"	.16																							.161	.150				
																									—	—				.33

E– See Stone Wall.

V– Upper figures are, equivalent of sizes in metric system

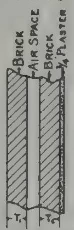
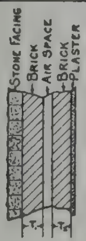
O See Brick Wall, furring, lath and plaster
See Stone Wall

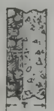
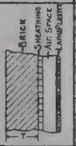
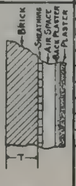
U– Average of values for various temperature differences.

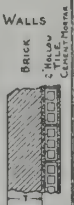
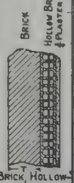
B. T. U. LOSSES—Jones Tables (Continued).

No. 1-K.

HEAT LOSS TABLES

WALLS	Thickness $T = T_1 + T_2$	Used by U of Pa A	Recknagel & Reitschel C	Peclet (Carpenter) E	Austrian Government (Macon) G		Greene 1913 I	Buffalo Forge Co J	Hubbard L	Thompson						Nat. Dist Heat Ass'n R	Busey U
										1 Wall Exposed	2 Walls Exposed	1 Wall Exposed 15% Added	2 Walls Exposed 15% Added	1 Wall Exposed 20% Added	2 Walls Exposed 20% Added		
										Furred and Plastered		Plastered Only		Without Furring or Plaster			
										Ha	Ha	Ha	Ha	Ha	Ha		
	4"	.36		.36													
	8"	.27	.25	.30	.23		.27	.25	.340							.25	.25
	12"	.22	.21	.25	.19	.27	.22	.21	.272	.220	.170	.253	.196	.264	.204	.22	.21
	16"	.19	.19	.21	.17	.22	.19	.19	.221							.19	.19
	18"	.17		.19						.175	.137	.201	.158	.201	.164		
	20"	.16	.16	.18		.19	.17	.16	.187	.160	.125	.184	.144	.192	.150	.16	.16
	24"	.15	.14	.17		.17	.15	.14	.170	.147	.115	.169	.132	.176	.138		
	28"	.13	.13	.15		.15	.13		.153	.135	.105	.155	.121	.162	.126		
Brick with Air Space	32"	.12	.12	.13		.13	.12			.117	.090	.135	.104	.140	.108		
¾" Plaster	36"	.12		.12		.12				.110	.084	.127	.097	.132	.101		
$T = T_1 + T_2$	40"	.11		.10		.11				.100	.077	.115	.089	.120	.092		
	30"	.13	Air Space 2.4"		Air Space 1"	Air Space 2"			No Plaster 85% of Plain Brick	.125	.097	.144	.112	.150	.116		
		A															
 Stone Facing Brick Air Space Brick Plaster T_1 T_2	8"	.25					.32										
	12"	.20					.20										
	16"	.17					.17										
	20"	.15					.15										
	24"	.14					.14										
	28"	.12					.12										
	32"	.12					.12										
$T = T_1 + T_2$				Given for brick or stone with air space. Does not state whether plastered or not	Does not state whether	plastered or not. Probably plastered										Given as brick, hollow and plastered	

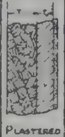
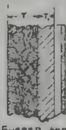
WALLS	Thickness T	Used by U of Pa A	Recknagel & Reitschel C	Nat Dist Heat Asso R	H & V Magazine X			
	12"	.45		—	.45			
	16"	.30		—	.39			
	20"	.35		—	.35			
	24"	.31		—	.31			
Concrete with Sandstone Facing	28"	.28	—	—	.28			
	32"	.26	—	—	.26			
			—	—				
			—	—				
		AA		RR				
		.17	—	.17				
			—	—				
			—	—				
			—	—				
			—	—				
			—	—				
			—	—				
 Brick Sheathing Air Space Back Plaster Plaster T		AAA		RRR				
		.14		.14				

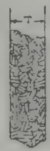
WALLS	Thickness T	Used by U. of P. A	Harding	Greene (1913) I				
	9"	.30	.24					
Brick, Hollow Tile, Cement Mortar			2" Hollow Tile, ½" Cement Mortar					
		AA		I				
	8"	.29		.29				
	12	.24		.24				
	16"	.20		.20				
	18"							
	20	.18		.18				
	21"							
	24"	.16		.16				
	27"							
	28	.14		.14				
	30"							
	32"	.13		.13				
Brick, Hollow-Brick-Furring Plastered One Side	33							
	36"							
	40"							

HEAT LOSS TABLES

Walls	Thickness T	Used by U of Pa. A	Greene 1913 I	Tweed Q	Nat Dist Heat Asso. R	Harding P	Heating and Ventilating Magazine WWa	WWb	WWc
Masonry with Plaster	8"								
	12"	.51	.51						
	18"	.43	.43						
	24"	.37	.37						
	30"	.32	.32						
	36"	.28	.28						
	48"		.23						
Hollow Fireproof Tile with Plaster Both Sides			II	QQ	RR	PP	WW	WW	WW
	Not Stated		.30	.30	.30				
	4"	.40				325	.79	.75	.34
	8"	.31					.56	.54	.27
	12"	.26					.44	.41	.26
	16"	.23					.40	.37	.23
	20"	.20					.33	.31	.20
	2"	.47				.409			
	6"	.36				.281			
Double Fireproof Tile with Plaster both sides Air Space in Center			III		RRR				
	Not Stated	21	.21		.21				

WWa Terra cotta or tile, plain.
WWb " " tile & stucco
WWc " " plaster

Walls	Brick Thickness T	Sandstone T	Plastered Used by U of Pa A	Recknagel & Reitschel C	Thompson He●	Thompson He▲	Thompson He*	H & V Magazine 1917 W	
Plain	4"	4"	.41		.324	.31	.270	.31	
	8"	4"	.34	.31	.230	.22	.192	.22	
	12"	4"	.28	.25	.178	.17	.148	.17	
	16"	4"	.23	.22				.21	
	20"	4"	.19	.19				.20	
	24"	4"	.17	.17				.17	
	28"	4"	.15	.15				.16	
 Plastered	4"	8"	.35		.303	.29	.252	.29	
	8"	8"	.28	.29	.205	.20	.174	.20	
	12"	8"	.24	.23	.167	.16	.139	.16	
	16"	8"	.20	.20				.20	
	20"	8"	.18	.18				.19	
	24"	8"	.16	.16				.16	
	28"	8"	.14	.14				.14	
 Furred and Plastered	4"	12"	.30		.271	.26	.226	.26	
	8"	12"	.25	.26	.198	.19	.165	.19	
	12"	12"	.21	.21	.157	.15	.131	.15	
	16"	12"	.19	.19	Plain	Plastered	Furred and Plastered	.19	
	20"	12"	.17	.17				.17	
	24"	12"	.15	.15				.14	
	28"	12"	.13	.13				.13	
			Plastered	Plastered				Given as Brick and Sandstone	
Brick with Sandstone Facing									

Walls	Thickness T	Used by U of Pa. A	Recknagel Reitschel C	Peclet (Carpenter) E	Austrian Gov. (Macon) G	Thompson He●	Thompson He▲	Greene 1913 I	Snow K	Hubbard L	Harrison M	Hoffman Brick+50% O	Tweed Q	Nat. Dist. Heat Asso. R	American Radiator Co. T	Prussian Gov Recknagel V	H G V Magazine 1917— W	Hauss Ger Practice X	Irwin Z
 Sandstone	12"	.48	.45	.32	.58	.54	.52	.54	.443		.45	.465	.28		.440	.451	.50	.45	.45
	16"	.41	.39	.28	.51	.47	.45		.385	.34	.39	.390			.360	.390	.45	.38	.38
	20"	.37	.35	.25	.45	.42	.40	.45	.357	.29	.35	.345			.307	.348	.40	.35	.35
	24"	.35	.31	.24	.41	.37	.36	.39	.300	.27	.32	.315	.23		.263	.318	.36	.32	.32
	28"	.29	.28	.22	.37	.34	.32		.270	.24		.285			.240	.287	.32	.29	
	30"	.28	—	—				.34			.28								Given as Solid Stone
	32"	.29	.26	.21	.33	.31	.30			.21		.255	.19		.214	.266	.23	.26	
	36"	.26	.24	.20	.31	.29	.28	.30	.243	Given as Solid Stone	.24				.200	.246		.24	
	40"	.25	.22	.18	.29	.26	.25	Given as Masonry				Given as Solid Stone			Brick +38⅓%	.226		.22	
	44"	.24	.21	.26 Given as stone or brick	Does not state whether plastered or not. Probably plastered				.200							.205		.20	
	48"	.23	.19					.24	Given for stone walls, rubble or block masonry							.195		.19	
	8"	.60										.600							
Sandstone with 2" Terra Cotta or Wood Furring and Plaster	12"	.40				.45		.28				.326	.28	.47					
	16"	.34				.39				.272		.273		.41					
	18"	.32						.25					.25						
	20"	.31				.35				.232		.242		.37					
	24"	.28				.31		.23		.216		.221	.23	.33					
	28"	.25				.28				.192		.200		.30					
	30"	.24						.21					.21						
	32"	.23				.26				.168		.179							
	33"	.23												.28					
	36"	.22				.24		.19		80% Value for unfurred wall			.19	.26					
	40"	.21				.22								.24					
	44"	.20												.20					
	48"	.19						.17					.17						
	8"	.50										.42							

He● Sandstone, Plain   * = Furred and Plastered Sandstone + 20%
He▲ Sandstone Plastered only = " " " " + 15%

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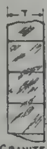
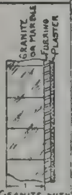
HEAT LOSS TABLES

Walls	Thickness T	Used by U. of Pa. A	Austrian Gov. (Macon) G	Recknagel Reitschel C	Peclet (Carpenter) E	Prussian Gov (Recknagel) V	Greene 1913 I	Snow (Sandstone+10%) K	Hubbard L	Hoffman Brick+50% O	Nat. Dist Heat. Asso. R	American Radiator Co. Brick+33⅓% T	H&V Magazine 1917— X	Thompson ● Ho	Thompson ▲ Ho	Hauss Ger. Practic. Y	Irwin Z	
Limestone	8"	.63								.600								
	12"	.51	.64	.49	.32	.496	.54	.487		.465		.440	.49	.598	.564	.485	.45	
	16"	.43	.56	.43	.28	.429		.424	.34	.390		.360	.46	.516	.495	.429	.39	
	18"	.41			.26		.45											
	20"	.39	.50	.38	.25	.383		.393	.29	.345		.307	.41	.456	.437	.385	.35	
	24"	.35	.45	.35	.24	.350	.39	.330	.27	.315		.263	.37	.420	.403	.352	.32	
	28"	.31	.41	.31	.22	.316		.299	.24	.265		.240	.33	.372	.357	.319		
	30"	.30					.34										Given as Solid Stone	
	32"	.29	.36	.28	.21	.293			.21	.255		.214	.29	.336	.322	.286		
	36"	.28	.34	.26	.20	.271	.30	.267	Given as Solid Stone	Given as Solid Stone		.200		.312	.299	.264		
	40"	.27	.32	.24	.18	.249	Given as Masonry							.298	.276	.242		
	44"	.26		.23	Given as Stone or Brick	.225		.220								.220		
	48"	.25		.21		.214	.24									.209		
Limestone with 2" Terra Cotta or Wood Furring and Plaster	12"	.43	Does not state whether plastered or not. Probably plastered				.28			.326	.52			.49				
	16"	.36							.272	.273	.46			.43				
	18"	.34					.25											
	20"	.32							.232	.242	.41			.38				
	24"	.29					.23		.216	.221	.38			.35				
	28"	.27							.192	.200	.34			.31				
	30"	.25					.21											
	32"	.24							.168	.179	.32			.28				
	36"	.23					.19				.29			.26				
	40"	.23					Given as Masonry		80% of unfurred limestone		.26			.24				
	44"	.22									.23							
	48"	.21					.17											

Ho ● Limestone, plain = Furred and plastered Limestone + 20%
Ho ▲ Limestone, plastered only = " " " " + 15%





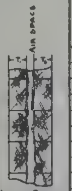
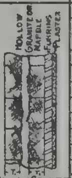
Walls	Thickness T	Used by U of Pa A	Thompson One Wall Exp	Thompson Two Walls Exp	Greene	Irwin	Nat Dist Heating Asso	Hubbard	American Radiator Co
Granite or Marble	8"								
	12"	.48	.480	.402	.54	.45			.440
	18"	.40	.408	.346	.45	.38		.34	.360
	21"	.37	.378	.330		.35		.29	.307
	24"	.34	.354	.312	.39	.32		.27	.263
	27"	.32	.338	.294				.24	.240
	30"	.30	.316	.278	.34	Given as Solid Stone			
	33"	.28	.300	.264				.21	.214
	36"	.27	.282	.252	.30			Given as Solid Stone	.200
	40"	.26	.264	.240					
	48"	.24			.24				
Granite with 2" Terra Cotta or Wood Furring and Plaster		A	HHo	HHo	I I		RR		
	8"								
	12"	.40	.400	.355	.28		.40		
	18"	.34	.340	.290	.25		.34	.272	
	21"	.32	.315	.275			.32	.232	
	24"	.30	.295	.260	.23		.30	.216	
	27"	.28	.280	.245			.28	.192	
	30"	.27	.265	.232	.21		.27		
	33"	.25	.250	.220			.25	.168	
	36"	.24	.235	.210	.19		.24		
	40"	.22	.220	.200			.22		
	48"				.17				

HHo Granite Wall, Furred and Plastered + 20%
I, II — Given as Masonry
E — Carpenter gives Stone same as Brick

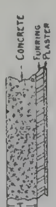
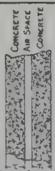
Walls	Thickness T = T₁ + T₂	Used by U of Pa A	Thompson 1 Wall Exposed Ho	Thompson 2 Walls Exposed Ho			
Granite or Marble Plastered only	12"	.46	.460	.385			
	18"	.38	.391	.334			
	21"	.36	.362	.316			
	24"	.33	.339	.299			
	27"	.31	.322	.282			
	30"	.29	.305	.267			
	33"	.27	.288	.253			
	36"	.26	.270	.242			
	40"	.25	.253	.230			
	48"	.23					
Hollow Granite or Marble Plastered only		AA	HHo	HHo			
	12"	.35	.351	.282			
	18"	.31	.311	.247			
	21"	.29	.293	.232			
	24"	.28	.276	.219			
	27"	.26	.262	.207			
	30"	.25	.251	.196			
	33"	.24	.239	.189			
	36"	.23	.230	.181			
	40"	.22	.219	.171			

Ho — Furred & Plastered Granite + 15%
HHo — Furred & Plastered Hollow Granite + 15%

HEAT LOSS TABLES

Walls	Thickness T = T₁ + T₂	Used by U. of Pa A	Thompson One Wall Exp He	Thompson Two Walls Exp He	Nat Dist Heat Asso R	Hubbard L	Peclet (Carpenter) P	
 Air space Hollow Granite or Marble T = T₁ + T₂	8						.30	
	12	.37	.366	.294			.25	
	18	.33	.324	.258		.289	.19	
	21	.31	.306	.242		.246	.18	
	24	.29	.288	.228		.229	.17	
	27	.28	.274	.216		.204	.15	
	30	.26	.262	.206		.179		
	33	.25	.250	.197		85% of Plain Wall	.13	
	36	.24	.240	.188			.12	
	40	.23	.228	.178			.10	
							.21	
 Hollow Granite or Marble, Furring, Plaster Hollow Granite or Marble with 2" Terra Cotta or Wood Furring and Plaster T = T₁ + T₂	8	A					Given as Brick or Stone with Air Space	
	12	.30	.305	.245	.30			
	18	.25	.270	.215	.21	.231		
	21	.23	.255	.202	.20	.187		
	24	.22	.240	.190	.19	.184		
	27	.21	.228	.180	.18	.163		
	30	.20	.218	.172	.17	.143		
	33	.19	.208	.164	.16	80% of Unfurred Hollow Wall		
	36	.18	.200	.157	.16			
	40	.17	.190	.149	.15			

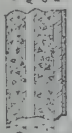
He = Hollow Granite, Furred and Plastered + 20%
Or Marble, " " " + 20%

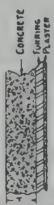
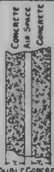
Walls	Thickness T = T₁ + T₂	Used by U of Pa A	Thompson He	Greene I	Busey U	Nat Dist Heat Asso R	Austrian Gov (Macon) G	Hubbard L	Buffalo Forge J
 Concrete, Furring, Plaster Concrete with 2" Terra Cotta or Wood Furring and Plaster	8	.63			.29		Does not state whether plastered or not, probably plastered	.528	.276
	12	.40	.45	.26	.29	.47		.384	.240
	16	.34	.39			.41		.312	
	18	.31		.24	.23			80% of Plain Concrete	.216
	20	.29	.35		.20	.37			.192
	24	.26	.31	.21		.33			Brick +20%
	28	.24	.28			.30			
	30	.23		.19					
	32	.22	.26						
	33	.22				.28			
	36	.20	.24	.17		.26			
	40	.18	.22			.24			
	44	.17				.20			
	48	.16		.15					
	4	.72							.336
 Concrete, Air Space, Concrete Double Concrete Wall with Air Space T = T₁ + T₂	8	.40					.30	.541	.300
	12	.37					.28	.408	.252
	16	.33					.26	.331	.228
	20	.29					.24	85% of Plain Concrete	.192
	24	.26					.22		
	28	.24					.20		.168
	32	.22					.19		
	36	.20					.18		
	40	.18					.17		

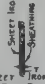
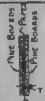
Walls	Thickness T	Used by U of Pa A	Austrian Gov. (Macon) G	Thompson He	Thompson Ha	Buffalo Forge Co Brick + 20% J	Hubbard L	Harrison M		American Rad. Co Brick + 50% T	H & V Magazine 1917 W	Greene I	Donnelly X	Irwin Z	Busey U			
Plain Concrete	2			.87*										.85				
	4	.90		.69*		.634		56		1.020	1.07		1.07	.785				
	6	.77		.59*							0.70		.714	.56				
	8	.63	.49	.49		.444	56	41		.690	0.51		.527	.49	.463			
	10	.56		.44*										.42				
	12	.48	.43	.54	.540	.342	.48	31		.495	0.43	.43	.357	.37	.363			
	16	.41	.37	.37	.461		39			.405	0.36		.257		.313			
	18	.38				.300						.38						
	20	.35	.33	.33	.420	.264				.345					.275			
	24	.31	.30	.30	.372					.300		.31			Brick + 25%			
	28	.28	.27	.27	.336	.228				.270								
	30	.27										.27						
	32	.26	.25	.25	.312					.240								
	36	.24	.23	.23	.288					.225		.24						
	40	.22	.22		.264							.19						
Concrete Plastered One Side		AA	Does not state whether plastered or not. Probably plastered		HHa	JJ					WW				UU			
	4	.82				.600					Concrete with Sandstone Facing							
	8	.59				.432									.450			
	12	.46			.518	.336					.45				.350			
	16	.39			.449	.288					.39				.300			
	20	.33			.403	.252					.35				.263			
	24	.29			.357						.31							
	28	.27			.322	.216					.28							
	32	.25			.299						.26							
	36	.23			.276													
	40	.21			.253													

Ha — Furred and Plastered Concrete + 20%
HHa — " " " " + 15%
Ha { Ascribed by Macon to Reitschel and for ordinary construction have been increased 25% (Above figures have been increased)

HEAT LOSS TABLES

Walls	Thickness T	A Used at U. of Pa.	C Busey	L Hubbard				
 Concrete with air space furred & plastered $T = T_1 + T_2$	6"	.38	.313	.449				
	12"	.30	.263	.326				
	16"	.25	.238	.265				
	20"	.20	.200					
	24"	.19		80% value for unfurred hollow wall				
	28"	.18						
	32"	.18						
	36"	.17						

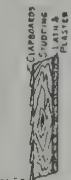
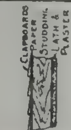
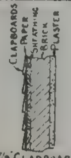
Walls	Thickness $T = T_1 + T_2$	A Used by U of Pa	H Thompson	I Greene	C Busey	R Nat Dist Heat Asso	G Austrian Gov (Macon)	L Hubbard	J Buffalo Forge
 Concrete with 2" Terra Cotta or Wood Furring and Plaster	8"	.63			.29			.528	.276
	12"	.40	.45	.26	.25	.47		.384	.240
	16"	.34	.39			.41		.312	
	18"	.31		.24	.23			80% of plain concrete	.216
	20"	.29	.35		.20	.37			.192
	24"	.26	.31	.21		.33			Brick + 20%
	28"	.24	.28			.30			
	30"	.23		.19			Does not state whether plastered or not. Probably plastered		
	32"	.22	.26						
	33"	.22				.28			
	36"	.20	.24	.17		.26			
	40	.18	.22			.24			
	44	.17				.20			
	48"	.16		.15					
	4"	.72							.336
 Double Concrete Wall with Air Space $T = T_1 + T_2$	8"	.48					.30	.561	.300
	12"	.37					.28	.408	.252
	16	.33					.26	.331	.228
	20"	.29					.24	85% of plastered concrete	.192
	24"	.26					.22		
	28"	.24					.20		.168
	32"	.22					.19		
	36"	.20					.18		
	40"	.18					.17		

Walls	Thickness T	A Used by U of Pa	J Buffalo Forge Co	L Hubbard	T American Rad Co (Brick + 20%)	C Busey		
 Reinforced Concrete	4"	.90		.80	.816			
	8"	.63		.55	.552			
	12"	.46		.40	.396			
	16"	.41			.324			
	20"	.35			.276			
	24"	.31			.240			
	28"	.28			.216			
	32"	.26			.192			
	36"	.24			.180			
 Sheet Iron on Pine Board Sheathing	½"	.50	.50			.50		
	1"	.40	.40			.40		
	1½"	.33	.33			.33		
	2"	.28	.28			.28		
	2½"	.25	.25			.25		
 Paper Between Pine Boards	½"	.32	.32			.32		
	1"	.24	.24			.24		
	1½"	.19	.19			.19		
	2"	.16	.16			.16		
	2½"	.14	.14			.14		

L- When furred & plastered take 80% of above values
- When hollow unplastered take 85%

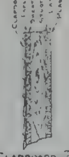
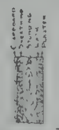
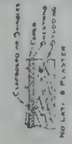
HEAT LOSS TABLES

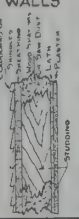
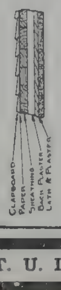
WOODEN WALLS	THICKNESS T	USED BY U OF PA A	B GERMAN GOV (WOLFF)	F PECLET CARPENTER	G AUSTRIAN GOV (MACON)		I GREENE 1913	J BUFFALO FORGE CO	K SNOW			R NAT DIST HEATING ASSN	T AMERICAN RAD. CO	U BUSEY	RECKNAGEL & RIETSCHEL PINE INNER C	PINE OUTER C	OAK INNER C	OAK OUTER C	P HARDING	Z IRWIN
 WOOD	3/8	.86		Given as solid wood Not applicable to wooden bldgs all [illegible] through crevices	.56							.56								29
	1/2	.78			.52			.77				.52		.77	.52	.56	.64	.70		
	3/4	.69			.44	.27	.55					.44			.44	.47	.59	.63		Frame house construction Thickness not given
	1	.59	.41		.91	.24	.48	.51				.41		.51	.39	.41	.54	.58	.547	
	1½	.51				.21	.40	.43	.30					.43	.31	.32	.47	.50	.370	
	2	.43			Given as wood plastered both sides		.34	.35	.257			.28		.35	.26	.27	.41	.43		
	2½	.39						.30	.228			Given as Pine Boards		.30	.22	.23	.37	.39	.279	
	3	.36						Given as Pine Boards	.20					Given as Pine Boards	.19	.20	.33	.35	Given as Solid wood Partition	
	3½	.32							Given as Pine Boards											
	4	.29		.120																.24
	8	.17		.065																.46
	12	.13		.045																
	16	.10		.033																Both values for factory buildings Thickness not given
	18	.09		.031	Interior Partitions								Wood wall Thickness not given							
	20	.08		.030																
	24	.07		.029																
	28	.06		.027																
	32	.05		.025																
	36	.05		.020																
	40	.04		.018																
	1¼"	.55											.22		.34	.36	.50	.54		

FRAME WALLS	THICKNESS	A USED BY U. OF PA.	D KINEALY	Ha THOMPSON	J BUFFALO FORGE CO	L HUBBARD	N ALLEN	O HOFFMAN	P HARDING	Q TWEED	R NAT DIST HEATING ASSN	I GREENE 1913	W H&V MAGAZINE 1917	X DONNELLY	Z IRWIN			
 CLAPBOARDS STUDDING LATH & PLASTER 7/16" CLAPBOARDS STUDDING, LATH & PLASTER		.45	.44	.44	.44	.30	.1	.25 to .30	.47	.2[illegible]	.45		.44	.471	.29			
	Without LLP	.48											.47		Frame house construction			
	Factory Bldgs														.24 to .46			
	Factory Bldgs																	
 CLAPBOARDS PAPER STUDDING LATH & PLASTER 7/16" CLAPBOARDS, PAPER, STUDDING, LATH & PLASTER		AA	DD	HHa	JJ	LL	NN	OO	PP	QQ	RR	II	WW	XX				
		.31	.31	.31	.31	.30	.1	.25 to .30	.34		.31		.31	.343				
	Without LLP	.34				For walls of the average wood dwelling	For ordinary wood house construction	For walls of the average wood dwelling					.34					
 CLAPBOARDS PAPER SHEATHING BRICK PLASTER 7/8" CLAPBOARDS PAPER SHEATHING, BRICK & PLASTER		AAA				LLL	NNN	OOO	PPP	QQQ		III	WWW					
		.30				.30	.1	.25 to .30	.21	.25		.20						
													.22 Clapboards brick lined & plastered					

UNIVERSITY OF ILLINOIS

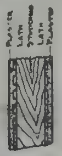
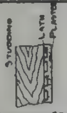
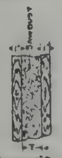
HEAT LOSS TABLES

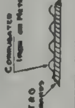
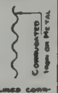
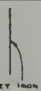
Frame Walls	Thickness	A Used By U. of Pa	D Kinealy	H Thompson	I Greene 1913	J Buffalo Forge Co.	K Snow	L Hubbard	N Allen	O Hoffman	P Harding	R Nat. Dist. Heating Asso	T American Ra Co.	W H&V Magazine 1917-	X Donnelly			
 Clapboard Paper Sheathing Studding Lath Plaster Clapboard 7/8 Paper, Sheathing 7/8 Studding, Plaster & Lath		.24	.25	.23	.20	.23	.228	.30	.1	25-30	.20	.24		.23	.257			
								For walls of the average wood dwelling	For ordinary wood house construction	For walls of the average wood dwelling	Given as wooden wall or floor							
		AA	DD	HH	II	JJ	KK	LL	NN	OO	PP	RR	TT	WW	XX			
 Clapboard 7/8 Sheathing 1/2 Lath Studding & Plaster		.29	.28	.28		.28	.286	.30	.1	2[illegible]-30	.30	.29	.280	.27	.30			
	Without L & P													30				
		AAA			III							RRR		WWW				
 Clapboard or Shingles Paper Sheathing Studding No Lath & Plaster		.29			.31							.27		.26				

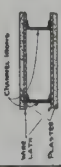
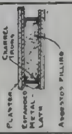
Walls	Thickness T	A Used By U. of Pa.	V Prussian Gov Recknagel	D Kinealy	I Greene	L Hubbard	O Hoffman	Q Tweed	R Nat Dist Heating Asso	W H&V Magazine 1917—	Y Hauss Ger Practice	G Austrian Gov (Macon)	X Donnelly					
 Clapboard or Shingles Sheathing Wood Shavings or Saw Dust Lath Plaster Studding		.10			.08			.10										
		AA	VV			LL	OO	QQ	RR	WW	YY	GG						
	1.6 to 2.6	.61	.615							Wire lath, cement plaster	.60	.62						
	2.6 to 3.2	.52	.492								.48	.59						
	2'	.60				.60	.60	.60	.60			.56						
	3"	.50				.50	.50	.50	.50			.53						
												.50						
	1½-2½	.61								.61		.47						
Plaster	3"-3½	.50								.49								
		AAA							RRR				XXX					
 Clapboard Paper Sheathing Back Plaster Lath & Plaster		.21							.21				.214					

B. T. U. LOSSES—Jones Tables (Continued).

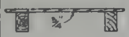
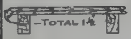
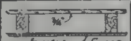
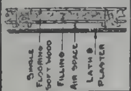
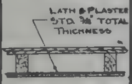
HEAT LOSS TABLES

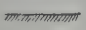
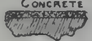
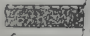
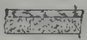
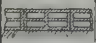
WALLS	THICKNESS T	A USED AT U. OF PA.	D KINEALY	H_1 THOMPSON	I GREENE 1913	J BUFFALO FORGE CO	K SNOW	O HOFFMAN	Q TWEED	R NAT. DIST. HEAT. ASSO.	W H.&V. MAGAZINE 1917	X DONNELLY
 ORDINARY STUD PARTITION PLASTER BOTH SIDES		.34	.34	.34	.36	.34	.143	.34	.34	.34	.34	.30
						A				4" STUDS		GIVEN AS PARTITION BETWEEN HEATED AND UNHEATED ROOM
 ORDINARY STUD PARTITION PLASTER ON ONE SIDE		AA	DD	HH_1	II	JJ	KK	OO	QQ	RR	WW	XX
		.62	.60	.6C	.49	.60	.257	.6	.49	.54	.60	.60
										4" STUDS		
 DOUBLE 1" BOARD WITH SAWDUST BETWEEN	SAW DUST	AAA				JJJ						
	2"	.13				.127						
	4"	.09				.083						
	6"	.06				.062						
	8"	.05				.049						

WALLS	THICKNESS	A USED AT U OF PA	H_1 THOMPSON	J BUFFALO FORGE CO	L HUBBARD	T AMERICAN RAD. CO.	W H&V MAGAZINE 1917	C DUSEY
 CORRUGATED IRON OR METAL LINED WITH T& G BOARDS			.17					
	½"	.45		.45				.45
	1"	.36		.36				.36
	1½"	.30		.30				.30
	2"	.26		.26				.26
	2½"	.23		.23				.23
 UNLINED CORRUGATED IRON OR METAL		AA	HH_1	JJ	LL	TT	WW	
		1.50	.84	1.50	1.20	.840	.84	
 SHEET IRON SIDING UNLINED		AAA		JJJ				
		1.20		1.20				

WALLS	THICKNESS	A USED AT U. OF PA.	I GREENE 1913	Q TWEED	R NAT DIST HEAT ASSO
		.34	.34		.34
 Channel Irons Plaster Expanded Metal Lath Asbestos Filling		AA	II	QQ	RR
		.21	.21	.21	.21
		AAA			

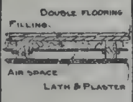
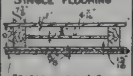
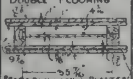
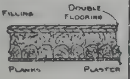
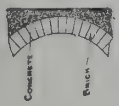
HEAT LOSS TABLES

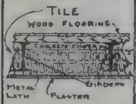
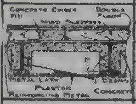
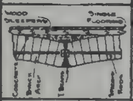
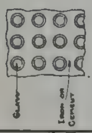
FLOORS	THICKNESS	USED AT U. OF PA. A	GERMAN GOV (WOLFF) B	D KINEALY	F B.F. STURTEVANT	Z IRWIN	G AUSTRIAN GOV. (MACON)	H0 THOMPSON	I GREENE 1913	J BUFFALO FORGE CO.	K SNOW	L HUBBARD	P HARDING	O HOFFMAN	Q TWEED	R NAT. DIST. HEAT ASSO	S PRACTICAL ENG	T AMER RAD CO	X DONNELLY	Y HAUSS	W H&V MAGAZINE 1917—
 SINGLE FLOOR. NO PLASTER BENEATH FLOOR		.29	.083	.45	.083		.33	.10	.33	.45	.186			.45	.40	.36		.083	.30		.45
			Given as wooden beam construction plastered over as floor probably construction [illegible]																		
 —TOTAL 1¼ DOUBLE FLOORING NO PLASTER BENEATH JOIST		AA		DD		ZZ		HHa	II	JJ	KK				QQ	RR				YY	WW
		.20		.31		.07		.08	.23	.31	.129				.27	.26				.07	.31
 SINGLE FLOOR LATH & PLASTER-¾"-BENEATH		AAA		DDD				HHHa	III	JJJ	KKK			OOO	QQQ	RRR			XXX		WWW
		.19		.26				.08	.031	.26	.114			.26	.20	.25			.20		.26
 SINGLE FLOORING SOFT WOOD FILLING AIR SPACE LATH & PLASTER		AAAA					GGGG									RRRR					WWWW
		.05					.05									.05					
							COLD AIR UNDER					GIVEN AS DOUBLE WOOD FLOOR	GIVEN AS WOODEN WALL OR FLOOR								
 DOUBLE FLOORING LATH & PLASTER BENEATH JOIST		AAAAA		DDDDD				HHHHH	IIIII	JJJJJ	KKKKK	LL LLL	PP PPP	OOOOO	QQQQQ	RRRRR	SS SSS				WW WWW
		.13		.18				.06	.030	.18	.071	.10	.20	.10	.10	.21	.10				.18

FLOORS	THICKNESS	USED AT U. OF PA A	THOMPSON H0b	GREENE 1913 I	BUFFALO FORGE CO. J	P HARDING	HAUSS, GER. PRACTICE Y	Q TWEED	NAT. DIST. HEAT ASSO. R	AMERICAN RADIATOR CO T	H&V. MAGAZINE 1917— W	IRWIN Z						
DIRT FLOOR SURFACE 		.20	.23		.20			.20	.13	.23	.23							
			GROUND TEMPERATURE ASSUMED TO BE 50°F															
CEMENT OR CONCRETE  EARTH		AA	HHa		JJ	PP	YY	QQ	RR	TT		ZZ						
		.31	.31		.31	1" 784	.08	.30	.29	.31		.29						
			HHb			3" 714	STONES LAID ON EARTH					STONES LAID ON EARTH						
			.30			4" 655												
						6" .563												
WOOD FLOORING  CEMENT OR CONCRETE		AAA	HHHa		JJJ			QQQ	RRR		WWW							
		.12	.08		.10			.10	.14		.10							
PLANK  ASPHALT		AAAA				PPPP	YYYY		RRRR			ZZZZ						
		.20					.20		.20			.20						
TILE  TILE ON GROUND NO WOOD FLOOR ABOVE		AAAAA	HHHHH	IIII	JJJJJ			QQQQQ	RRRRR									
		.31	.31		.31			.30	.29									
			GROUND TEMPERATURE ASSUMED TO BE 50°F															

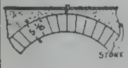
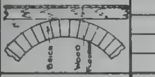
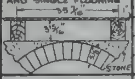
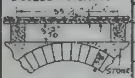
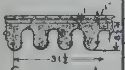
PP— 1" FINISH ON TOP NOT SPECIFIED WHETHER FLOOR OR CEILING EARTH UNDER CONCRETE NOT SHOWN

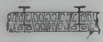
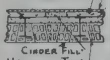
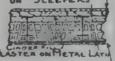
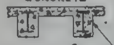
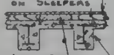
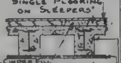
HEAT LOSS TABLES

FLOORS	THICKNESS	USED AT U. OF PA. A	C RECKNAGEL & RIETSCHEL	G AUSTRIAN GOV. (MACON)	J BUFFALO FORGE CO.	L HUBBARD	O HOFFMAN	Q TWEED	R NAT. DIST. HEAT ASSO.	W H & V. MAGAZINE	Y HAUSS GER. PRACTICE						
		.05		.045					.05								
				GIVEN AS FLOOR WITH COLD AIR UNDER													
SINGLE FLOORING		AA	CC		JJ												
 PROBABLY LATH & PLASTER		.07	.07		.07												
DOUBLE FLOORING		AAA	CCC		JJJ												
 PROBABLY LATH & PLASTER		.06	.06		.06												
		AAAA		GGGG													
		.06		.055													
CONCRETE FLOOR ON BRICK ARCH		AAAAA				LLLLL	OOOOO	QQQQQ		WWWWW	YYYYY						
		.20				.20	.20	.20		.20	.20						
											GIVEN AS STONE FLOOR ON ARCHES						

FLOORS FIRE PROOF	THICKNESS T	USED BY U. OF PA. A	B GERMAN GOV. (WOLFF)	F B. F. STURTEVANT CATS. 84 & 215 (A. R. WOLFF)	H THOMPSON	I GREENE	N ALLEN	O HOFFMAN	Q TWEED	S PRACTICAL ENG.	T AMERICAN RAD. CO.	X DONNELLY					
 TILE WOOD FLOORING CONCRETE CINDER METAL LATH PLASTER GIRDERS			.124	.122		.29	.124	.10	.10	.2	.124						
	9"	.15					GIVEN AS FIRE-PROOF FLOOR WITH WOOD FLOORING				GIVEN MERELY AS FIRE PROOF FLOORING						
	12"	.10															
	15"	.06															
		AA		FF		II	NN	OO			TT	XX					
 CONCRETE CINDER FILL DOUBLE FLOOR WOOD SLEEPERS METAL LATH PLASTER REINFORCING METAL I BEAMS CONCRETE		.15	.124	.122		.025	.124	.10			.124	.428					
						.25?						CONCRETE WITH CINDER FILL					
		AAA															
		AAAA				IIII											
 WOOD SLEEPERS SINGLE FLOORING CONCRETE BRICK ARCH I BEAM WOODEN ROD		.10				.25											
VAULT LIGHT		AAAAA		FFFFF													
		1.43		1.43													

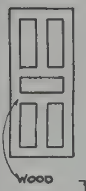
HEAT LOSS TABLES

FLOORS	THICKNESS	USED BY U. OF PA A	C RECKNAGEL & REITSCHEL	H THOMPSON	L HUBBARD	O HOFFMAN	J BUFFALO FORGE CO	R NAT DIST HEAT. ASSO	T AMERICAN RAD CO.	W H.&V MAGAZINE 1917—	Y HAUSS GER PRACTICE	Z IRWIN
ARCH WITH STONE FLOORING  5⅝ STONE		.20	.21 DOES NOT STATE WHETHER FLOOR OR CEILING								.20	.20
SINGLE WOOD FLOORING ON BRICK ARCH  BRICK WOOD FLOOR		AA .09			LL .15	OO .15				WW .15	YY .09 GIVEN AS ARCH WITH AIR SPACE	
ARCH WITH SLEEPERS AND SINGLE FLOORING  35 7/16" 3 15/16" STONE		AAA .09	CCC .09 HEATED ROOM ABOVE AN UNHEATED ROOM									
DOUBLE FLOORING  35 3 13/16 STONE		AAAA .08	CCCC .06							WWWW .10		
 31½ CORRUGATED IRON AND CONCRETE WITH DOUBLE FLOORING FIRE PROOF		AAAAA .13	CCCCC .13 NOTE: DOES NOT STATE WHETHER FOR FLOOR OR CEILING. ASSUMED TO BE FOR FLOOR.	HHHHH			JJJJJ .13	RR-RR	TTTTT			

CEILINGS FIREPROOF HOLLOW TILE	THICKNESS	USED BY U OF P A	GERMAN GOV (WOLFF) B	D.E. STURTEVANT CAT'S 84 & 215 (WOLFF) F	AUSTRIAN GOV (MACON) G	THOMPSON H	GREENE I	ALLEN N	O HOFFMAN	P HARDING	Q TWEED	NAT DIST HEAT ASSO R	T AMERICAN RAD CO	PRACTICAL ENG. S	W H & V MAGAZINE	X DONNELLY
 HOLLOW TILE		.39				.39					.40	.37				
SINGLE FLOORING, ON SLEEPERS  CINDER FILL HOLLOW TILE		AA .18				HHo .10			OO .14		QQ .15	RR .18				
SINGLE FLOORING ON SLEEPERS  CINDER FILL PLASTER ON METAL LATH HOLLOW TILE		AAA .15	BBB .145	FFF .145	ASSUMING TEMPERATURE OF ATTIC AS 30°F. ABOVE THE LOWEST OUTSIDE TEMPERATURE	HHHo .15	III .14	NNN .145	OOO .14		QQQ .15		TTT .145 GIVEN AS FIREPROOF CEILING		WWW .20 FIREPROOF FLOOR AS CEILING	
REINFORCED CONCRETE  REINFORCED CONCRETE		AAAA .39	GIVEN AS FIREPROOF CONSTRUCTION FLOOR AS WELL			HHHHo .39		GIVEN MERELY AS FIREPROOF CONSTRUCTION			QQQQ .40	RRRR .37				
SINGLE FLOORING ON SLEEPERS  CINDER FILL REINFORCED CONCRETE		AAAAA .26	?			HHHHHo .10			OOOOO .14		QQQQQ .15	RRRRR .18				XXXXX .428
SINGLE FLOORING ON SLEEPERS  CINDER FILL PLASTER ON METAL LATH REINFORCED CONCRETE		AAAAAA .19	BBBBBB .145	FFFFFF .145		HHHHHH .15	IIIIII .15	NNNNNN .145	OOOOOO .14		QQQQQQ .15	RRRRRR	TTTTTT .145 GIVEN AS FIREPROOF CEILING			

HEAT LOSS TABLES

DOORS



Thickness	Used at U. of Pa. A	German Gov. (Wolff) B	Recknagel & Reitschel C				B.F. Sturtevant Cat. 84 6215 (A. R. Wolff) F	Austrian Gov. (Macon) D				Greene 1913 I	Buffalo Forge Co. J	Harrison M	Allen N	Tweed Q	Nat. Dist. Heat. Asso. R	Practical Eng. S	American Rad. Co. T	Hauss Gen. Practice Y	H & V Magazine W	Hoffman O	Hubbard L	Prussian Gov. (Recknagel) V	Irwin X		
			Pine		Oak			Soft Wood		Hard Wood																	
			Inner	Outer	Inner	Outer		Inner	Outer	Inner	Outer																
½"			.52	.56	.64	.70																					
¾"			.44	.47	.59	.63		.46	.49	.60	.69	.55															
1"			.39	.41	.54	.58		.39	.42	.54	.63	.48	.41			.48					1.00	.40	.40				
1¼"			.34	.36	.50	.54															Given as door or single glass						
1½"			.31	.32	.47	.50		.31	.33	.47	.53	.40	.32			.43											
2"			.26	.27	.41	.43		.26	.28	.42	.46	.34	.27			.31						.36	.30				
2½"			.22	.23	.37	.39		.21	.23	.37	.41																
3"			.19	.20	.33	.35							Given as pine door														
Standard Thickness		.414																.40	.42	.40				.410	.414		
																									.572		
Type																				Thickness not given					Given as wood and glass door		
Outside Doors	.56											.55			.42	.48			Given merely as door								
Inside Doors	.40											.34				.31											
65% wood 35% glass	.57						.572										Storm										
Double Doors	.27																.27										
Single Door 1¾ thick	.44																.44										
Ditto, weather stripped	.34																.34										
Plain Door	.42						.414							.41													

Standard Thickness

● — For outside doors.
⊗ — For inside doors

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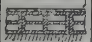
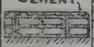
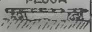
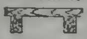
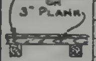
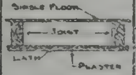
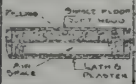
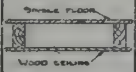
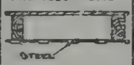
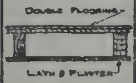
FLOORS	THICKNESS	USED BY U. OF PA. A	GERMAN GOV. (WOLFF) B	RECKNAGEL & REITSCHEL C	BY STURTEVANT CATS. 84 & 215 (A.R. WOLFF) F	THOMPSON H	GREENE 1913 I	BUFFALO FORGE CO. J	ALLEN N	HOFFMAN O	TWEED Q	NAT. DIST. HEAT. ASSO. R	H. & V. MAGAZINE W	DONNELLY X	HAUSS GER. PRAKTIS Y	IRWIN Z			
WOOD FLOORING  TILE ON GROUND		.11				.08		.10 TEMPERATURE OF EARTH GIVEN 30°-50° F			.10	.14							
CEMENT  TILE ON GROUND		AA											WW						
		.30											.30						
SINGLE FLOOR  WITH SLEEPER ON EARTH		AAA				HHHa		JJJ				RRR	WWW		YYY	ZZZ			
		.13				.10		.10				.13 PLANKS LAID ON EARTH PROBABLY NO SLEEPERS	.10		.16 PLANKS LAID ON EARTH	.16 PLANKS LAID ON EARTH PROBABLY NO SLEEPERS.			
						HHHb													
						.10													
WOODEN BEAMS PLANKED OVER AS FLOORING 		AAAA	BBBB		FFFF				NNNN	OOOO		RRRR		XXXX					
		.13	083 GIVEN AS WOODEN BEAM CONSTRUCTION PLANKED OVER AS FLOORING SEE FOLLOWING SHEET #32		083 PROBABLY MEANT FOR USUAL FLOOR OF JOISTS & BOARDS.				.083 SEE SHEET NO 32	.17 DIMENSIONS NOT GIVEN. STANDARD 12"x12" BEAM AND 3" PLANK ASSUMED		.13 MILL CONSTRUCTION		.214 MILL CONSTRUCTION					
STANDARD WOOD FLOORING ON 3" PLANK  12"x12" WOOD GIRDERS		AAAAA					IIIII												
		.15					.16												

CEILINGS	THICKNESS	USED BY U OF PA A	AUSTRIAN GOV (MACON) G	THOMPSON Ha	GREENE 1913 I	HOFFMAN O	TWEED Q	NAT. DIST. HEAT. ASSO. R	DONNELLY X								
LATH & PLASTER WITH SINGLE FLOOR ABOVE 		.25		.26 ASSUMING TEMPERATURE IN ATTIC AT 30°F ABOVE LOWEST OUTSIDE TEMPERATURE	.13	.25	.25	.28	.45								
		AA	GG					RR									
		.10	.10					.10									
		AAA						RRR									
		.29						.29									
STEEL CEILING WITH FLOOR ABOVE 		AAAA				OOOO	QQQQ	RRRR									
		.35				.35	.35	.35									
		AAAAA			IIIII												
		.25			.16												

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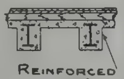
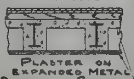
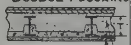
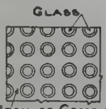
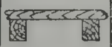
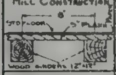
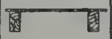
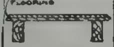
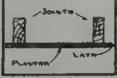
CEILINGS	THICKNESS	USED BY U OF PA A	GERMAN GOV (WOLFF) B	B.F. STURTEVANT CATS 84 & 215 (A.R. WOLFF) F	AUSTRIAN GOV. (MACON) G	THOMPSON Ho	GREENE I	ALLEN Z	HOFFMAN O	TWEED Q	NAT DIST. HEAT. ASSO R	PRACTICAL ENG. S			
DOUBLE FLOORING ON SLEEPERS  REINFORCED CONCRETE		.24			.24						.24				
DOUBLE FLOORING ON SLEEPERS  PLASTER ON EXPANDED METAL REINFORCED CONCRETE		AA		FF	GG		II				RR				
	WITH AIRSPACE	.19		1.45	.187		.15				.19				
	WIT														
DOUBLE FLOORING  TILE OR CONCRETE FILLING PLASTER ON EXPANDED METAL REINFORCED CONCRETE	T	AAA			GGG						RRR				
	6"	.16			.16						.16				
	7"	.14			.14										
	8"	.12			.12						.12				
	9"	.11			.11										
	10"	.10			.10						.10				
	12"	.09			.09										
	15"	.08			.08						.08				
	20"	.07			.07										
GLASS  IRON OR CEMENT VAULT LIGHT		AAAA		FFFF							RRRR	SSSS			
		1.43		1.43							1.46 GIVEN FOR SIDEWALK	1.4			

CEILINGS	THICKNESS	USED BY U OF PA A	GERMAN GOV (WOLFF) B	KINEALY D	B F STURTEVANT CATS 84 & 215 (WOLFF) F	THOMPSON Ho	GREENE 1913 I	SNOW K	ALLEN Z	HOFFMAN O	TWEED Q	NAT. DIST. HEAT. ASSO. R	AMER RAD. CO T	H & V MAGAZINE 1917 E	HAUSS GEN PRACTICE Y	AUSTRIAN GOV (MACON) G	DONNELLY X	IRWIN N			
WOODEN BEAMS PLANKED OVER AS CEILING 		.30	.104		.104 PROBABLY REFERS TO USUAL WOOD FLOOR OF JOISTS AND BOARDS				.104	.35											
MILL CONSTRUCTION  8' 3" TOP FLOOR 5" PLANK WOOD GIRDERS 12"×12"		AA					II										XX				
		.19					.10					.19 GIVEN AS MILL CONSTRUCTION					.214				
SINGLE FLOOR ABOVE 7/8 NO PLASTER BELOW 		AAA	BBB		FFF		III					RRR	TTT		YYY	GGG		ZZZ			
		.40	.104 [illegible]		.104		.33					.40'	.104		.10	.33		.10			
DOUBLE FLOORING 		AAAA					IIII														
		.23					23														
LATH & PLASTER NO FLOOR ABOVE  JOISTS PLASTER LATH		AAAAA		DDDDD		HHHHH		KKKKK		OOOOO	QQQQQ	RRRRR		EEEEE			XXXXX				
		.45	[illegible]	.62 [illegible]		.32		.257 ASSUMING THE ATTIC TEMPERATURE AT 30°? ABOVE THE LOWEST OUTSIDE TEMPERATURE		.62	.50	.45		.62			.50				

1- BUFFALO FORGE COMPANY — NO DISTINCTION BETWEEN FLOORS AND CEILINGS — SEE FLOORS

EXPOSURE CONSTANTS

		A Used by U of Pa	D German Gov Buff. Forge	O Kinealy	G Austrian Gov. (Macon)	I Thompson	H Greene	F Hubbard	Z Allen	O Hoffman	O Hoffman Ger Gov	Recknagle	Reitschel	Klinger	P Harding	T Amer. Rad. Co	X Donnelly	Y Hauss	
1	North	.40	.10		.20	.25	.15	.32	.10	.10;.20	.15;.25	.25	.10		.15 .30	.10	.10	.10	
2	East	.10;.20			.15	.10	.10	.12		.05;.10	.10;.15		.10		.10 .20			.10	
3	South	—	—	—	—	—	—	—	—	—	—	-	-	-	—	-	-	—	—
4	West	.20;.30			.15	.15	.10	.20		.05;.10	.10;.15				.10 .20			.10	
5	Northeast	.20;.30						.22		.10;.20	.15;.25	.25	.10		.15 .30			.10	
6	Northwest	.40						.26		.10;.20	.15;.25	.25	.10		.15 .30			.10	
7	Southeast	—						.06											
8	Southwest	—						.10											
9	North, East South & West	—						.16											
10	Heated Intermittently	.50	.50				.50		.40;.50	.20;.40	.50					.30			
11	Daytime only Unexposed	.10	.10	.10			.10		.10		.10					.10			
12	Daytime Only Exposed	.30	.30	.30			.30				.30	.20				.20			
13	Exposed to Heavy Winds	—					.15		.30		.10;.20	.20 .30	.10			.10		.05	
14	12' to 14½' High	See Formula		.03							.03								
15	Above 15' High											.10						.033	
16	14½' to 18' High			.065							.06							.066	
17	Above 18' High			.10							.10							.10	
18	Corner Walls	—		.05			.10							.20					
19	Air Leakage	—			.10														

COVERED IN SELECTING OTHER EXPOSURE CONSTANTS

14-D —— 13 TO 14½' HIGH

10-I —— AT LONG INTERVALS.

11-I & 11-Ob—DAYTIME ONLY—CLOSED AT NIGHT

12-I & 12-Ob—DAYTIME ONLY—OPEN AT NIGHT

11-N —— DAYTIME ONLY ALLOWED TO COOL AT NIGHT

13-N —— NORTHERN EXPOSURE

1-5-6-Ob—ROOMS HEAVILY EXPOSED

16Y —— ABOVE 15' HIGH

$$t' = t + 0.03(h - 10)t$$

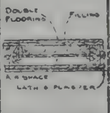
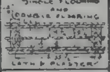
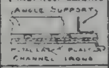
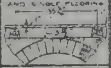
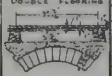
$$t_1 = \frac{t' + t}{2} = t + 0.015(h - 10)t$$

t' is temperature of air at ceiling
t_1 is mean temperature
t is temperature at floor
h is ceiling height
t_1 should not be greater than 115t.

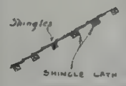
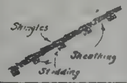
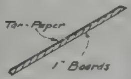
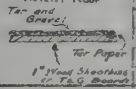
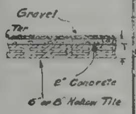
AMOUNTS TABULATED ABOVE ARE PERCENTAGES TO BE ADDED TO HEAT LOSS FOR NORMAL SOUTHERN EXPOSURE

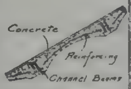
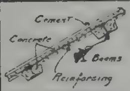
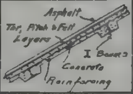
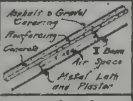
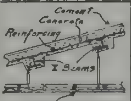
HIGHER AND LOWER FIGURES FOR MAXIMUM & MINIMUM EXPOSURES

CEILINGS

Ceilings	Thickness	A Used at U of Pa	C Recknagle & Reitschel	G Austrian G	H Greene	I Thompson	J Buffalo Forge	O Tweed	R Nat'l Dist Heat Ass'n	Y Hauss	Z Irwin
		.09		.088					.09		
Single Flooring and Double Flooring 		AA	CC	GG			JJ				
			Single Flooring								
		.10	.10	.10			.10				
			Double Flooring								
		.09	.09				.09				
Fireproof Ceiling 		AAA				III		OOO	RRR		
		.43				.49		.50	.43		
Arch with sleepers and single flooring 		AAAA	CCCC		HHHH					YY YY	ZZ ZZ
		.14	.15		.25					.14	.14
Brick Arch with sleepers & double flooring 		AAAAA	CCCCC								
		.12	.12								

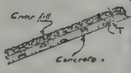
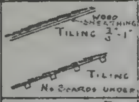
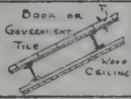
HHHa — Assuming temperature of attic as 30° F. above lowest outside temperate.

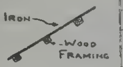
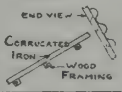
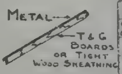
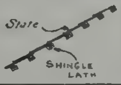
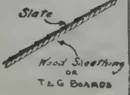
ROOFS	THICKNESS T	USED BY U OF PA A	AUSTRIAN GOV (MACON) G	THOMPSON H	GREENE (1913) I	BUFFALO FORGE CO J	HUBBARD L	HARRISON M	TWEED Q	NAT'L DIST HTG. ASSO R	PRACT ENG S	AMER RAD CO. T	DONNELLY X	H. & V MAGAZINE W			
		.63			.42					58	.90						
		AA			II					RR			XX				
		.32			.31					.34			.296				
		AAA	GGG							RRR							
		.44	.436							.44							
PATENT ROOF  Tar and Gravel Tar Paper 1" Wood Sheathing or T. & G. Boards		AAAA	GGGG	HHHH		JJJJ		MMMM		RRRR		TTTT	XXXX	WWWW			
	1" Boards	.30		.30		.30		.27		.30		.30	.286	.30			
	2" Boards	.26				.26		Given as Asphalt Roof		.26		Given as Composition Roof					
	Mag. Tar & Gravel	.21											.21				
		AAAAA		HHHHH 4		JJJJJ	LLLLL			RRRRR				WW WWW			
	8"	.38		.40		.35	.36			.40				.36			
	10"	.36		.36						.35							
	8" Tile 4" Conc.	.40					.40							.40			

ROOFS	THICKNESS	USED BY U. OF PA. A.	GERMAN GOV. (WOLFF) B.	PECLET CARPENTER E	AUSTRIAN GOV. (MACON) G.	THOMPSON H.	GREENE I.	BUFFALO FORGE CO J.	HUBBARD L	HARRISON M.	TWEED Q.	NAT. DIST HTG. ASSO. R.	PRACT ENG. S.	AMERICAN RAD. CO. T	HARDING P	IRWIN Z	
		.50															
		AA			GG		II				QQ	RR					
		.50			.57		.42				.43	.57					
 Asphalt Tar, Pitch & Felt Layers I Beams Concrete Reinforcing		AAA			Original gives varying values from .190 for 23" I Beam & 4.8' span to .202 for 21.7" I Beam & 32' span					MMM					PPP	ZZZ	
		.38								.27 Asphalt Roof					.60 3" Concrete [illegible]	.27 Asphalt Roof	
 Asphalt & Gravel Covering Reinforcing Concrete I Beam Air Space Metal Lath and Plaster		AAAA			GGGG							RRRR					
		.20			.20 Roof shown as horizontal							.20					
 Cement Concrete Reinforcing I Beams Metal Lath & Plaster Ceiling hung from Beams.		AAAAA					IIII										
		.22					.22										

B. T. U. LOSSES—Jones Tables (Continued).

HEAT LOSS TABLES

ROOFS	Thickness T	Used by U of Pa A.	German Gov. B	Austrian Gov. (Macon) G	Thompson Ha	Greene I	Buffalo Forge Co. J.	Hubbard L.	Tweed Q.	Nat. Dist. Heat. Asso. R.	Pract. Eng. S	Amer. Rad. Co. T	Donnelly X	Harrison M	H. & V. Magazine W	Irwin Z
	2"	.80					.80			.80		Given as Cement Roof				
	4"	.60			.60		.60	.60	.60	.60					.60	
	6"	.53			.54		.54	.54	.50	.54					.54	
	Thickness not given											.60	.428		With Tar & Gravel Finish	
 Wood Sheathing Tiling 3/4"-1" Tiling No Boards Under		AA		GG	HHa		JJ			RR		TT		MM	WW	ZZ
	3/4"-1"	.80			.80		.80			.80					.80	1.0
														Tile Roof		Tiling with 4" Framing
	No Board Under	1.12		.99						1.12		1.25		1.0		
		AAA				III				RRR						
	2½-3"	.25								.25						
	Book Tile	.25				.25										
	Gov. Tile	.35				.35										

ROOFS	Thickness	Used by U of Pa A.	Austrian Gov. Macon G.	Thompson Ha	Buffalo Forge J	Hubbard L	Harrison M	Tweed Q	Natl. Dist. Htg. Asso. R	Pract. Eng. S	Amer. Rad. Co. T	Donnelly X	H. & V. Magazine W	Irwin Z
	Unlined Metal	1.30		1.30		1.30			1.26				1.30	
	Iron	1.30		1.32	1.20			1.20	Given as Sheet Iron					
					Given as Sheet Iron			Given as Sheet Iron						
		AA	GG		JJ		MM	QQ	RR					ZZ
		1.87	2.13		1.5		2.14	1.5	1.81					2.14
														With 4" Framing
		AAA	GGG	Hobb		LLL	MMM		RRR		TTT	XXX	WWW	ZZZ
	Iron	.28		.17		.17			.28		.17		.17	
	Copper or Zinc	.45	.44				.45		.44					.45
	Tin	.31										.314		Copper on 1" Boards
		AAAA		HHHHa	JJJJ				RRRR	SSSS			WWWW	
		.88		.80	.85				.83	1.1			.80	
				HHHHb										
				.82										
		AAAAA	GGGGG	HHHHHa	JJJJJ	LLLLL	MMMMM	QQQQQ	RRRRR		TTTTT	XXXXX	WW WWW	ZZ ZZZ
		.38	.43	.30	.43	.30	.45	.43	.38		.30	.371	.30	.43
				Tight Wood Sheathing	On 1" Boards		For Copper, Zinc & Slate		On 1" Boards					On 1" Boards
				HHHHHb										
				.30										

EXPOSURE.

The exposure factor is closely allied to the leakage factor inasmuch as the exposure factor usually covers a greater percentage than the simple difference in outside air temperature would produce. In proof of this it is a generally accepted fact that the outside air on the south side of a building will average about 10 degrees warmer than on the north side during the day. Yet many methods of computing radiation involve an increase of 25% to 33 1/3% for north exposure.

For well-constructed buildings in locations of only reasonable exposure the additional allowance for exposure should be made as follows:

Unventilated Rooms.		*Ventilated Rooms.*
South	0%	10%
East	10%	20%
West	10%	20%
North	15%	25%

For badly exposed buildings a larger allowance for exposure should be made as follows:

Unventilated Rooms.		*Ventilated Rooms.*
South	10%	20%
East	20%	30%
West	20%	30%
North	25%	35%

The reason for allowing a little higher exposure factor in the ventilated rooms is that such rooms have no leakage figured (as is explained under "Leakage") and, on windy days when the room is on the windward side, the cold air may rush in around the windows to a discomforting degree unless some little additional surface is provided.

On the other hand, in an unventilated room leakage for a complete change of air every hour is figured and this is sufficient to care for all ordinary contingencies.

LEAKAGE.

Leakage is the most variable quantity with which the designer of a heating plant has to deal. At the time a heating system is designed it is to a great extent a gamble on what the final construction of a building will be, and many contemplated helps to the heating of a building may later be abandoned in order to cheapen up the cost. Metal sash, weather-strips, double windows, etc., may never finally be used, however positively they may at first be specified, and too much dependence must not be placed on such aids.

In the ordinary, well-constructed building the figuring of *one air change per hour* for leakage in all unventilated rooms and spaces will be entirely sufficient. This has been proven time and again in practical experience and, while at certain widely-separated times the leakage may exceed this, these periods are of such short duration that there is enough leeway on the amount of surface installed to carry over such a brief time without any serious discomfort.

BTU REQUIRED PER CUBIC FOOT FOR VARIOUS AIR CHANGES AND TEMPERATURE RANGES.

Temp Rise Degrees Fahr	No of Air Changes per Hour								
	½	1	1½	2	3	4	5	6	10
5	0.05	0.09	0.14	0.18	0.27	0.36	0.45	0.55	0.91
10	0.09	0.18	0.27	0.36	0.55	0.73	0.91	1.09	1.82
15	0.14	0.27	0.41	0.55	0.82	1.09	1.36	1.64	2.73
20	0.18	0.36	0.55	0.73	1.09	1.45	1.82	2.18	3.64
25	0.23	0.45	0.68	0.91	1.36	1.82	2.27	2.73	4.55
30	0.27	0.55	0.82	1.09	1.64	2.18	2.73	3.27	5.45
35	0.32	0.64	0.95	1.27	1.91	2.55	3.18	3.82	6.36
40	0.36	0.73	1.09	1.45	2.18	2.91	3.64	4.36	7.27
45	0.41	0.82	1.23	1.64	2.45	3.27	4.09	4.91	8.18
50	0.45	0.91	1.36	1.82	2.72	3.64	4.55	5.45	9.09
55	0.50	1.00	1.50	2.00	3.00	4.00	5.00	6.00	10.00
60	0.55	1.09	1.64	2.18	3.27	4.36	5.45	6.55	10.91
65	0.59	1.18	1.77	2.36	3.54	4.72	5.91	7.09	11.82
70	0.64	1.27	1.91	2.54	3.82	5.09	6.36	7.64	12.72
75	0.68	1.36	2.05	2.73	4.09	5.45	6.82	8.18	13.63
80	0.73	1.45	2.18	2.91	4.36	5.82	7.27	8.72	14.54
85	0.77	1.55	2.32	3.09	4.64	6.17	7.73	9.27	15.45
90	0.82	1.64	2.46	3.27	4.91	6.55	8.18	9.83	16.36

Note—This table based on 1 B.T.U. raising 55 cu. ft. of air 1° F.

Example:

A room 14 ft. x 14 ft. x 10 ft. has a radiation loss of 5,000 B.T.U. and a leakage loss estimated at 1½ changes per hour with outside air 10° F., and inside temperature of 70° F. This is a temperature rise of 70° — 10° = 60°.

In the table, under 1½ air changes and opposite 60°, is found the factor 1.64. The cubic contents, 14 x 14 x 10 or 1960 cu. ft. x 1.64 = 3214 B.T.U. for leakage.

Total loss = 5000 + 3214 = 8214 B.T.U.

TEMPERATURE RANGE

A building in a given locality is subject to certain environments which have much to do in deciding its heating requirements.

It may be exposed to cold winds and set on a prominent elevation or it may be in a sheltered position and protected by hills, forests, or other nearby buildings.

The temperature range in a given locality may be extreme for long and continuous periods of time or it may reach an extreme but rarely and, then, for a brief interval of hours only.

A locality which goes down to zero only once in two or three years and which has the zero weather last only a half a day or less can safely be figured for 5° or even 10° above zero. But for a locality which goes down to 5° above and then hovers around such a temperature for a week or more it would be much wiser to figure it at zero.

LOWEST TEMPERATURES IN THE UNITED STATES.

State and City	Lowest Temp. Degrees Fahr.
Alabama	
Birmingham	2
Mobile	—1
Montgomery	—5
Arizona	
Flagstaff	—17
Phoenix	12
Yuma	22
Arkansas	
Fort Smith	—15
Little Rock	—12
California	
Fresno	20
Independence	10
Los Angeles	28
Sacramento	19
San Diego	32
San Francisco	29
Colorado	
Denver	—29
Grand Junction	—16
Pueblo	—27
Connecticut	
Hartford	—14
New Haven	—14
Southington	—19
District of Col.	
Washington	—15
Florida	
Jackson	10
Key West	41
Pensacola	7
Tampa	19
Georgia	
Augusta	3
Atlanta	—8
Savannah	8
Idaho	
Boise	—28
Lewiston	—18
Pocatello	—20
Illinois	
Cairo	—16
Chicago	—23
Springfield	—22
Indiana	
Indianapolis	—25
Evansville	—15
Iowa	
Des Moines	—30
Dubuque	—32
Keokuk	—24
Sioux City	—3
Kansas	
Concordia	—25
Ft Dodge	—26
Wichita	—22
Kentucky	
Louisville	—20
Louisiana	
New Orleans	7
Shreveport	—5
Maine	
Eastport	—21
Portland	—17
Maryland	
Baltimore	—7

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LOWEST TEMPERATURES IN THE UNITED STATES.

STATE AND CITY	LOWEST TEMP. DEGREES FAHR.
Massachusetts	
Boston	—13
Michigan	
Alpena	—27
Detroit	—24
Marquette	—27
Pt. Huron	—25
Minnesota	
Duluth	—41
Minneapolis	—33
Moorhead	—48
St. Paul	—41
Mississippi	
Meridian	—6
Vicksburg	—1
Missouri	
Hannibal	—20
Kansas City	—22
St. Louis	—22
Springfield	—29
Montana	
Havre	—55
Helena	—42
Kalispell	—28
Miles City	—49
Nebraska	
North Platte	—35
Lincoln	—26
Omaha	—32
Valentine	—38
Nevada	
Carson City	—22
New Hampshire	
Concord	—35
New Jersey	
Atlantic City	—7
Cape May	—7
New Mexico	
Roswell	—18
Santa Fe	—13
New York	
Albany	—24
Binghamton	—26
Buffalo	—14
New York	—6
Oswego	—23
Saranac Lake	—38
North Carolina	
Charlotte	—5
Hatteras	8
Wilmington	5
North Dakota	
Devils Lake	—51
Bismarck	—44
Williston	—49
Ohio	
Cincinnati	—17
Columbus	—20
Toledo	—16
Oklahoma	
Oklahoma	—17
Oregon	
Baker City	—20
Portland	—2
Roseburg	—6
Pennsylvania	
Erie	—16
Philadelphia	—6
Pittsburgh	—20
Rhode Island	
Providence	—12
Block Island	—4
South Carolina	
Charleston	7
Columbia	2
South Dakota	
Huron	—43
Pierre	—40
Yankton	—32
Tennessee	
Chattanooga	—10
Knoxville	—16
Memphis	—9
Nashville	—13
Texas	
Amarillo	—16
Corpus Christi	—11
El Paso	—5
Ft. Worth	—8
Galveston	8
San Antonio	4
Utah	
Salt Lake City	—20
Vermont	
Burlington	—25
Northfield	—32
Virginia	
Lynchburg	—6
Norfolk	2
Washington	
Seattle	12
Spokane	—30
Walla Walla	—17
West Virginia	
Elkins	—21
Parkersburg	—27
Wisconsin	
La Crosse	—43
Milwaukee	—25
Wyoming	
Cheyenne	—38
Lander	—36

TEMPERATURE RANGE

NO. 4-A

PROPER TEMPERATURES FOR VARIOUS ROOMS.

Rooms.	*Degrees F.*
Bath Rooms	70 to 85
Boiler Shops	50 to 60
Churches	65
Cooling Rooms (Bath Houses)	59
Entrance Halls	54–60
Factories	65
Foundries	50–60
Gymnasiums	60
Homes for Aged	80
Hospitals	72–75
Hot Air Baths (Bath Houses)	140
Hot Rooms (Bath Houses)	77
Lecture Halls	60–64
Living Rooms	68
Massage Rooms (Bath Houses)	77
Machine Shops	60–65
Offices	68
Operating Rooms	70–90
Paint Shops	80
Prisons—Day Confinement	64
Prisons—Night Confinement	50
Public Buildings	68–72
Schools	70
Shops	65
Sick Rooms	72
Steam Baths (Bath Houses)	113
Swimming Halls	68
Vestibules	54–60
Warm Air Baths (Bath Houses)	122

DUCTS AND FLUES.

Computing Heat Losses.

There is only one method which can produce accurate results in the computation of heat losses and that is the B. T. U. system. The accuracy of the results attained by using B. T. U. is only limited by the accuracy of the designer in computing the areas of his surfaces and the correctness of his factors for the given construction. All rules of thumb give approximate results only and these usually for certain standard-sized rooms of regular construction.

Heat will gradually transfer from a warm object to a cold one until the temperature of each is the same at which time the interchange of heat ceases. Thus a warm room loses heat to a colder one, to the outside air, to the attic, or to any other adjacent space where the temperature is lower than that maintained in the room.

A room will also absorb heat from an adjacent apartment if the apartment is kept at a higher temperature than the room. For this reason cold attics over warm rooms are generally figured as being at 40° F. if the rooms are 70° and the outside temperature zero. Similarly unheated space under a room is generally considered as being at 35° F. under similar conditions.

Thus to get the entire B. T. U. loss for a room *all* the surfaces separating the room from colder conditions must be counted as positive heat losses (the exact amount being the area exposed times the heat loss coefficient CE times the difference in temperature between the two spaces) and all the surfaces separating the room from warmer spaces must be similarly figured as negative losses, the algebraic sum of two giving the net radiation loss for southern exposure.

Outside walls and glass must have the exposure factor figured but on inside walls, glass, ceilings and floors it is not necessary to consider the exposure factor.

To the net transmission loss, with the proper increase for exposure must be added the leakage loss—if the room is unventilated—and the total will be the gross loss upon which to base the required radiator surface.

Briefly these may be summarized as follows:

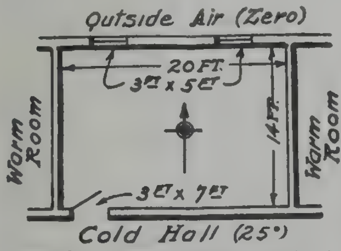
SUMMARY OF B. T. U. METHOD OF HEAT LOSS CALCULATION.

1. Compute all wall surfaces exposed to the outside air in one direction only.
2. Compute all the glass and door surface in the same wall.
3. Subtract the glass and door surface from the gross wall surface leaving the net wall surface.
4. Multiply the glass surface by the proper factor for the temperature difference assumed.
5. Multiply the net wall surface by its proper factor similarly.
6. Add the wall and glass loss and increase for exposure as per the percentages given on Sheet No. 2.
7. Follow similar procedure for other outside walls.
8. Compute inside walls, ceilings, and floors where spaces on the other side are at temperatures different from the assumed room temperature, and multiply by proper factor for each construction and its respective temperature difference, making spaces warmer than the room negative losses.
9. Take the algebraic sum of all the losses computed and add leakage loss if room is unventilated. This will be the total B. T. U. loss.

COMPUTING HEAT LOSSES.

Example of Computing by B. T. U. Method.

Problem: A room 14 ft. x 20 ft. x 10 ft. high, with only reasonable exposure, is to be heated to 70° F. in zero weather; it has a warm cellar below and a cold attic above; the construction is frame and the plan as shown herewith.



The outside wall area is 20 ft. × 10 ft. ...... = 200 sq. ft.
The window area is 5 ft. × 3 ft. .... = 30 sq. ft.

Net area .... = 170 sq. ft.

Frame house: loss for clapboards, paper, sheathing, lath and plaster for 70° — 0°, or 70° temperature difference = 16 B. T. U. (See Sheet No. 1-E.) Loss for glass, single thick, for 70° = 70 B. T. U. (See Sheet No. 1-F.)

Wall loss = 170 sq. ft. × 16 B. T. U. = 2720 B. T. U.
Glass loss = 30 sq. ft. × 70 B. T. U. = 2100 B. T. U.

Sum (for southern exposure) .. = 4820 B. T. U.

Room is unventilated and has north exposure. Therefore, the exposure factor (Sheet No. 2) is 15%, or 723 B. T. U. On the inside walls, all are warm except the hall wall which is 20 ft. × 10 ft. gross, or 200 sq. ft. The door equals 3 ft. × 7 ft., or 21 sq. ft. The net wall equals 179 sq. ft. Glass loss for 45° F. (Sheet No. 1-F) = 45 B. T. U. Wall loss for 45° F., for plastered stud walls (Sheet No. 1-E) = 15 B. T. U.

Inside wall loss = 179 × 15 = 2635 B. T. U.
Inside glass loss = 21 × 45 = 945 B. T. U.

Sum of inside wall losses = 3630 B. T. U.

As the cellar is warm no loss is figured on the floor, but with a cold ceiling (at 40° attic space above the ceiling) the area is 14 ft. × 20 ft. = 280 sq. ft. and the factor for 35° difference (Sheet No. 1-G) is 9 B. T. U. = 280 × 9 = 2520 B. T. U.

At one air change the cubic contents of 14 ft. × 20 ft. × 10 ft. = 2800 cu. ft. which at 70° F. (See Sheet No. 3) = 2800 × 1.27 = 3556 B. T. U. for leakage.

The total B. T. U. loss equals the sum of all the various losses computed, or:

	B. T. U.
Outside wall and glass	4820
Exposure	723
Inside wall and glass	3630
Ceiling loss	2520
Leakage	3556
	15249 Total B. T. U. Loss.

COMPUTING HEAT LOSSES.

Equivalent Inside Temperature for Direct Radiation.

The question is often raised as to what temperature would be maintained inside of a building with a direct heating system which would give 70° F. when it is zero outside or any other arbitrarily assumed temperatures. Table I covers this matter in an unusually complete form.

In using Table I the factor at the bottom of each column is of great importance being the *number of degrees additional* which will be realized in the *indoor* temperature for *each degree* the outside temperature is *above* the *specified* temperature.

Example:—A given job is specified to heat to 70° F. in zero weather with 5 lbs. steam on. At time of test it is 20° F. outside (average) and steam is at 3 lbs. What will the resultant inside temperature be if the apparatus is large enough to fulfill the specified conditions?

The figures in Table I are the resulting temperatures with the outside at *zero* and the steam pressure varied Thus, in the above case, if the outside were zero and the temperature inside 70° with 5 lbs. of steam, with 3 lbs., by the table, it would be 68.3° F. But with the outside temperature 20 above the "factor" of 0.692 at the bottom of the column must be multiplied by 20 and this result *added* to the temperature *given by the table.*

Thus:— 0.692 × 20 =	13.84°	correction for outside 20°
	68.30	temperature for corrected steam pressure and zero
	82.14°	resultant inside temperature

Table 1.

Actual Steam Pressure Under Test	Corresponding Steam Temperature	Steam Pressure To Be Used Under Specification, Pressure, Pounds Gauge.										
Vacuum In.	Degrees F.	0	1	2	3	4	5	6	7	8	9	10
10	192	63.3	62.3									
9	194.5	64.2	63.2	62.3								
8	197	65	64	63	62.2							
7	199	65.6	64.7	63.7	62.8	62						
6	201	66.3	65.3	64.3	63.4	62.6	62					
5	203	67	66	65	64	63.3	62.6	61.9				
4	205	67.6	66.6	65.6	64.7	63.9	63.2	62.5	61.7			
3	207	68.3	67.2	66.2	65.3	64.5	63.8	63.1	62.3	61.7		
2	208.5	68.8	67.7	66.7	65.7	65	64.2	63.6	62.8	62	61.5	
1	210.5	69.4	68.3	67.5	66.4	65.6	64.8	64.2	63.3	62.6	62.1	61.5
Gauge Lbs.												
0	212	70	68.8	67.8	66.9	66.1	65.3	64.6	63.8	63.1	62.6	62
1	215.5	71.2	70	69	68	67.2	66.3	65.8	65	64.2	63.7	63
2	218.7	72.1	71	70	69.2	68.2	67.3	66.7	65.9	65.1	64.5	64
3	221.7		72	71	70	69.2	68.3	67.6	66.7	66	65.4	64.8
4	224.5			71.8	70.8	70	69.2	68.4	67.5	66.7	66.2	65.7
5	227.2				71.7	70.8	70	69.2	68.3	67.6	67	66.3
6	229.8					71.7	70.8	70	69.2	68.4	67.7	67.2
7	232.4						71.7	70.9	70	69.2	68.6	68
8	234.9							71.7	70.8	70	69.3	68.7
9	237.3								71.5	70.5	70	69.3
10	239.4									71.3	70.7	70
Factors for each degree outside temperature varies from specified temperature		0.67	0.675	0.678	0.684	0.688	0.692	0.694	0.698	0.702	0.705	0.707

HEAT LOSSES FOR VENTILATED ROOMS.

The calculation of heat losses for ventilated rooms involves the omission of the leakage losses and the raising of the exposure factors about 10% as explained in detail on Standard Data Sheet No. 2. Owing to the leakage varying between one-half to two air changes per hour (usually approximating one air change) and the ventilation running from four to twenty air changes per hour (usually approximating six to eight air changes) the leakage in ventilating rooms becomes relatively of minor importance.

In ventilated rooms two conditions may occur: (a) the room may be supplied with 70° air and all the heat losses made up by direct radiation; or, (b), the air may be heated up to whatever degree is necessary to make up the heat losses. In the first instance the system is what is known as a combination "direct-indirect system" with the air supplied purely for ventilation purposes, while in the second case the air is supplied for heating as well as ventilating the system, in this event being usually termed a "hot-blast system" of heating.

Suppose the room taken for example in Standard Data Sheet No. 5-A (May, 1917, issue) is to be ventilated with air at 70° F. so as to give ten air changes per hour. What will be the size of direct radiator, the number of cubic feet of air per minute, the area of the duct and the gross area of the register?

According to the summary of heat losses presented in Standard Data Sheet No. 5-A these losses for a ventilated room will be:

4820	B. T. U. for outside wall and glass
1205	B. T. U. for exposure (increased to 25%)
3630	B. T. U. for inside wall and glass
2520	B. T. U. for ceiling
0	B. T. U. for leakage
12175	B. T. U. for total loss

The 12,175 B. T. U. may be reduced to direct radiator surface, as outlined in Standard Data Sheet No. 13, and the quantity of air per minute may be determined by the use of the formula;

$$\frac{CF \times C}{60} = C.F.M.$$

When C. F. M. is the cubic feet per minute required.
C F is the cubic feet contained in the room.
C is the number of air changes per hour.

Then

$$\frac{2800 \times 10}{60} = 466 \text{ cu. ft. per minute.}$$

At a velocity in the entering duct of, say, 400 ft. per minute, the area of the duct will be 466/400 = 1.16 sq. ft. and the net area of the register, at 250 ft. per minute velocity, will be 466/250 = 1.86 sq. ft., which must be increased about 50% to get the gross area 1.86 + (1.86 x .50) = 1.86 + 0.93 = 2.79 sq. ft. gross area.

The heat required for this air may be calculated by the use of the formula:

$$B.T.U. = \frac{60 \ CFM \times R}{50}$$

When B. T. U. is the heat required per hour.
C F M the cubic feet of air per minute.
R the rise in temperature in the air.

Then

$$B.T.U. = \frac{60 \times 466 \times 70^\circ}{50} = 39144 \text{ B. T. U.}$$

This added to the B. T. U. for direct radiation makes a total of

12175	B. T. U. for direct radiation.
39144	B. T. U. for ventilation.
51319	B. T. U. total

COMPUTING HEAT LOSSES.

Heat Losses in Fan Blast Heating.

If the room is to be heated by the air, as well as ventilated, then the temperature of the air must be raised sufficiently above 70° so that the *surplus* heat in the air will be sufficient to make up the radiation losses of the room. Uusally 120° to 140° is considered as the practical limits of heating the air so that when the temperature of the air would have to exceed this it is customary to increase the quantity of air on *account of the heating requirement.*

Under ordinary conditions the quantity of air required for ventilation is more than sufficient to supply the necessary heat and this is found to be the case in the example cited, as is later demonstrated.

The amount of air heated 1° F. by 1 B. T. U. varies slightly at different temperatures and humidities, as is shown in the two right-hand columns of the table giving the "Properties of Air" published on Standard Data Sheet No. 9. It is quite usual, however, to consider that 50 cu. ft. may be raised 1° F. with 1 B. T. U. or that 1 cu. ft. may be raised 50° F. by 1 B. T. U. While this is not absolutely correct it is entirely close enough for all ordinary work and facilitates the calculations; when greater accuracy is desired 55 may be substituted for 50.

In the room in question (see Data Sheet No. 5-D) it has been determined that the heat loss is
12175 B. T. U. per hour
and the air per hour is 466 × 60, or
27960 c. f. h.

The increase in air temperature may be calculated from the formula

$$I = \frac{B.T.U.}{C.F.H.} \times 50$$

When I is the increase in temperature in degrees above the room temperature and B. T. U. and C. F. H. are the B. T. U. loss and cubic feet of air supplied,—both per hour.
When the increase in air temperature must be

$$I = \frac{12175}{27960} \times 50 = 21° \text{ plus, say } 22° \text{ F.}$$

As the room temperature is 70° then the air temperature will be $70 + 22 = 92°$ in order to heat the room.

Proofs: During the course of one hour 27,960 cu. ft. of air enter the room. Each cubic foot cools from 92° down to 70° (the room temperature), or 22°. As each cubic foot would have to cool 50° in order to give up 1 B. T. U. in cooling 22° it gives up only 22/50 B. T. U. or 0.44 B. T. U. 27950 cu. ft. × 0.44 B T. U. = 12,300 B. T. U. supplied, against 12,175 B. T. U. required

The total quantity of heat is then
$60 \times 466 \times 92/50 = 51200$ B. T. U.
if the air is assumed to be heated from zero.

COMPUTING HEAT LOSSES.

Equivalent Hot Blast Temperatures for Other Temperatures than Zero.

The temperature that a fan blast system under test should maintain when the outside temperature is other than zero may be obtained from the formula

$$T = \frac{t_g\,(t_s - t_o) \quad t_s\,(t_o - t_{os})}{t_s - t_{os}}$$

when T is the resultant building temperature when the outside temperature is t_o,

t_g the guaranteed building temperature at a specified outside temperature (t_{os}),

t_{os} the outside temperature specified,

t_s the temperature of the steam at the pressure stipulated,

t_o the actual outside temperature.

From this formula Table I has been calculated and shows what temperature should be reached for any guarantee with any outside temperature.

TABLE I.

Outside Temp. Deg. F.	Average Indoor Temperature—T Deg. F.							
—20	45.2	50.8	56.1	61.6	67.1	72.5	77.9	83.4
—15	48.9	54.3	59.7	64.9	70.3	75.6	80.9	87.3
—10	52.9	57.9	63.1	68.3	73.5	78.7	86.0	89.2
— 5	56.3	61.4	66.5	71.6	76.8	81.9	87.0	92.1
0	60.	65.	70.	75.	80.	85.	90.	95.
5	63.7	68.6	73.5	78.4	83.2	88.1	93.0	97.9
10	67.4	72.1	76.9	81.7	86.5	91.3	96.0	100.8
15	71.0	75.7	80.3	85.1	89.7	94.4	99.1	103.7
20	74.7	79.3	83.9	88.4	92.9	97.5	102.1	106.6
25	78.4	82.9	87.3	91.8	96.2	100.7	105.1	109.5
30	82.1	86.4	90.8	94.1	99.4	103.8	108.1	112.4
35	85.8	90.0	94.3	97.5	102.6	106.9	111.2	115.3
40	89.4	93.6	97.7	101.8	105.9	110.0	114.2	118.2
45	93.1	97.1	101.2	105.4	109.1	113.2	117.2	121.1
50	96.8	100.7	104.7	108.5	112.4	116.3	120.2	124.0
55	100.5	104.3	108.1	111.9	115.6	119.4	123.3	126.9
60	104.2	107.8	111.6	115.2	118.8	122.6	126.3	129.8
65	107.8	111.4	115.0	118.6	122.1	125.7	129.3	132.7
70	111.5	115.0	118.5	121.9	125.3	128.8	132.4	135.6

(Buffalo Forge Co.)

COMPUTING HEAT LOSSES.

Heating and Ventilation Calculation Sheet.

In the accompanying heating and ventilation calculation sheet, space is allowed for four different exposures and the losses for each wall are placed opposite the proper exposures. Space is also provided for the ceiling, and floor, and also four lines for any miscellaneous items of losses of a special nature. On the bottom line below the theoretical radiator surface can be placed the actual radiation installed, and the total radiation for each sheet is placed over in the right-hand corner. These sheet totals are carried from sheet to sheet until the floor is completed. When starting on a new floor a new total is developed and carried along. On the last sheet a summary is made floor by floor, the grand total being the radiation required for the building.

HEATING & VENTILATION CALCULATION SHEETS

First Floor
Sheet No 1

JOB John Brown's Residence
LOCATION Brownsville
TEMPERATURE 0° to 70° = 70° Rise
DATE May 1, 1920
ESTIMATED BY H. L. A.
CHECKED BY H. B.

LOCATION OF LOSSES			ROOM NO. 1			ROOM NO. 2			ROOM NO 3			ROOM NO. 4		
DESCRIPTION OF LOSSES		%	SQ. FT.	FACTOR	B. T. U.	SQ. FT.	FACTOR	B. T. U	SQ. FT.	FACTOR	B. T. U.	SQ. FT.	FACTOR	B. T. U.
NORTH	GROSS WALL		200									80		
	GLASS		30	70	2100							21	70	1470
	NET WALL		170	20	3400							59	20	1180
	TOTAL				5500									2650
	EXPOSURE	20			1100									530
	TOTAL				6600									3180
WEST	GROSS WALL					150						100		
	GLASS					30	70	2100				30	70	2100
	NET WALL					120	20	2400				70	20	1400
	TOTAL							4500						3500
	EXPOSURE	10						450						350
	TOTAL							4950						3850
SOUTH	GROSS WALL		200						80					
	GLASS		45	70	3150				8	70	560			
	NET WALL		155	20	3100				72	20	1440			
	TOTAL				6250						2000			
	EXPOSURE													
	TOTAL				6250									
EAST	GROSS WALL		100											
	GLASS		15	70	1050									
	NET WALL		85	20	1700									
	TOTAL				2750									
	EXPOSURE	10			275									
	TOTAL				3025									
CEILING OR ROOF														
FLOOR			200	10	2000	150	10	1500	64	10	640	80	10	800
1 AIR CHANGE			3000	1.2	3600	1500	1.2	1800	640	1.2	768	800	1.2	960
MISCELLANEOUS														
GRAND TOTAL B.T.U.					21475			8250			3408			8790
RAD EFFICIENCY				250				33.0						
RADIATION SURFACE THEORETICAL					85.9			33.0			6.8			35.1
					86			32			9			36

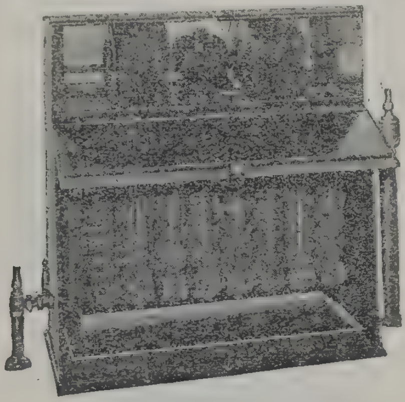
163 sq. ft.

PORTABLE UNIT VENTILATORS

Peerless Unit Ventilators

In the Peerless unit ventilator, use is made of an especially-designed Vento radiator. The complete unit, which includes fans and motor, is entirely enclosed in a cabinet of furniture steel and finished in olive green. The unit is arranged to admit fresh air from out-of-doors, the exact form of fresh-air intake depending, in each instance, upon the building construction at the point of application. The fresh air is taken in at as high a level as possible to prevent dirt, leaves, etc. from being drawn in. As an extra precaution the inlet is covered with a screen or grille.

The air is circulated by a constant-speed motor, with extended shafts on which are mounted two aluminum multiblade fans. These fans are arranged to operate at a speed not exceeding 900 R. P. M. The Vento radiator used is located in the heating chamber. There is also a water reservoir in the bottom of the cabinet which acts as a deflector to the incoming air, at the same time removing dust and dirt and humidifying the air. The heated and washed air is delivered through an opening in the face of the unit and directed towards the ceiling.



The Peerless Unit Ventilator.

With this system exhaust ventilation is accomplished through the use of an exit grille located near the floor through which the used air may pass to a flue or directly to the outside of the building.

Recirculation of air is provided for through a recirculating intake consisting of a full-length-hinged door at the top of the unit. A grille is fastened inside the cabinet, and painted to match the exterior finish, to prevent foreign matter from entering at that point. The fresh-air inlet has louvre dampers so connected with the recirculating door at the top of the unit that the opening of one has a corresponding opposite effect upon the other.

There is also in this unit an additional air-mixing damper, operated by manual or automatic control, to provide a wide range of temperature regulation by directing the air flow through the radiator or, to the extent desired, through a by-pass. All incoming air, however, passes through the unit and over the water in the water-pan.

The radiator valves are kept open to assure ample steam supply and are provided with lock shields and key to prevent tampering. All control of the room temperature is obtained with the air-mixing damper. With the damper in the cold position and

(*Continued on Data Sheet No. 6-A*)

PORTABLE UNIT VENTILATORS

Peerless Unit Ventilators

(Continued from Data Sheet No. 6)

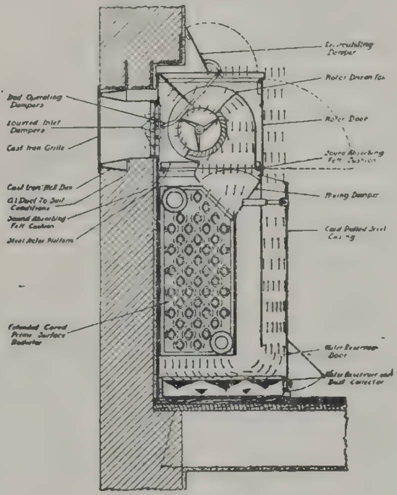
outside air at between 60° and 70° F., the Peerless unit, according to the manufacturer's guarantee, is able to pass all the air around the radiator in the unit and discharge it at a temperature rise not exceeding 5° F.

Automatic control of the air mixer is secured by means of a diaphragm motor inside the cabinet, controlling the mixing damper. A two-point compound thermostat operates the damper motor and the valves on the auxiliary direct radiation.

Sound and vibration-absorbing felt cushions are fitted to the steel platform, on which are mounted the motor and fan, to secure noiseless operation. Care has also been taken to use direct-current motors so as to eliminate all magnetic motor noises.

DIRECTIONS FOR LAYING OUT SYSTEM.

First determine the amount of air required for ventilation, figuring on 30 cu. ft. per minute per pupil in the classrooms, and from four to six changes per hour for such rooms as assembly halls and gymnasiums. The size of units having been decided on from the above information and from Table 1, the location of the unit and the method of making the fresh-air inlet should be determined.



TYPICAL METHOD OF INSTALLING PEERLESS UNIT VENTILATORS, WITH AIR INTAKE THROUGH WALL

To determine the amount of direct radiation required, the radiation is computed in the regular way and then the amount shown in the table for the particular unit chosen should be deducted. The remainder is the amount that must be added in direct radiation. The manufacturers recommend the installation of separate direct radiation so that if the electric current should be shut off and the fan kept out of operation the room can still be heated. It is pointed out that the unit itself does not contain enough radiation to heat the average-size classroom when the fans are inoperative, having about the same usefulness as 75 sq. ft. of direct radiation.

Three methods of venting are suggested. In the first method venting is accomplished through an independent flue, usually located in the cloakroom. This is described as the most satisfactory way of venting classrooms. The second method is venting through independent flues in the classrooms. In the third method, especially where buildings have no provision for mechanical ventilation, the venting may be through the corridor and into a main vent flue located in the corridor. However, in some states this would not meet the legal requirements.

This system is manufactured by the Peerless Unit Ventilation System, 437-439 West 16th Street, New York.

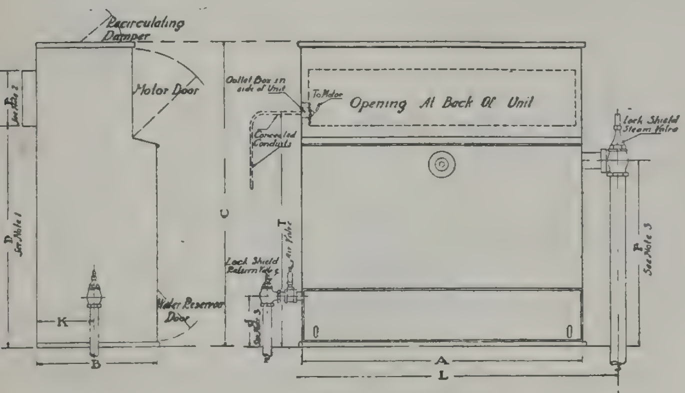
(Continued on Data Sheet No. 6-B)

PORTABLE UNIT VENTILATORS

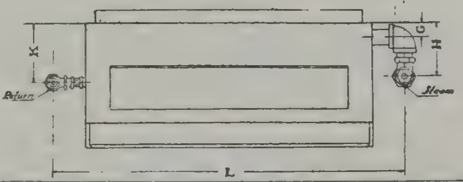
Peerless Unit Ventilators

(*Continued from Data Sheet No. 6-A*)

SIZES, CAPACITIES AND DIMENSIONS OF PEERLESS HEATING AND VENTILATING UNITS



The Peerless Unit is made in six different sizes as shown in the table below:



Unit Number	Cu. Ft. Air per Min. Note 4	Final Temperature Note 4	Total B.t.u. Note 4	General Dimensions Notes 1 and 2				
				A	B	C	D	E
720	900	72°	77250	33″	18⅛″	42″	29½″	8″
724	900	83°	89600	33″	18⅛″	46″	33½″	8″
920	1200	74°	10600	42″	18⅛″	42″	29½″	8″
924	1200	83°	119500	42″	18⅛″	46″	33½″	8″
1120	1500	72°	128700	51″	18⅛″	43″	29½″	8″
1124	1500	80°	144000	51″	18⅛″	47″	33½″	8″

Unit Number	Steam Supply Notes 3 and 5			Return Notes 3 and 5			Pipe Sizes			Size F. A. Duct	Size Wall Box
	F	G	H	J	K	L	R	S	T		
720	24″	2⅛″	See Note 6	7½″	8¾″	43½″	1″	1½″	31″	10″x30″	10″x30″
724	28″	2⅛″		7½″	8¾″	43½″	1″	1½″	35″	10″x30″	10″x30″
920	24″	2⅛″		7½″	8¾″	52½″	1″	2″	31″	10″x40″	10″x40″
924	28″	2⅛″		7½″	8¾″	52½″	1″	2″	35″	10″x40″	10″x40″
1120	24″	2⅛″		7½″	8¾″	61½″	1″	2″	31″	10″x50″	10″x50″
1124	28″	2⅛″		7½″	8¾″	61½″	1″	2″	35″	10″x50″	10″x50″

Note 1.—Dimension D is the minimum and can be increased to suit height of window.

Note 2.—Dimension E is the inlet collar on back of unit. Duct connecting to this collar should be 10 inches deep.

Note 3.—Dimensions F and J are to bottom of unit. Dimensions to floor will vary with window heights and floor levels.

Note 4.—Final temperature can be increased by cutting down cu. ft. of air per min. This will change total B.t.u.

Note 5.—Steam connection on right hand side of unit, return connection on left hand side. This can be reversed where building conditions render necessary.

Note 6.—H = 2⅛″ + distance from center of ell to center of valve used.

(*Concluded on Data Sheet No. 6-C*)

PORTABLE UNIT VENTILATORS

Peerless Unit Ventilators

(Concluded from Data Sheet No. 6-B)

ENGINEERING DATA ON PEERLESS UNITS

For delivery of stated quantities of air and maintaining a room temperature of 70 deg. fahr., with steam at 5 lb. gauge pressure

—Indicates standard mechanism. Other quantities obtained by putting speed controllers on motors

	Entering Air at −10 Deg. Fahr.					Entering Air at 0 Deg. Fahr.					Entering Air at + 10 Deg. Fahr.				
Unit Number	Cubic Feet of Air per Minute	Final Temp. Deg. Fahr.	Total B.t.u.	Direct Radiation to be Omitted	Condensation Pounds per Hour	Cubic Feet of Air per Minute	Final Temp. Deg. Fahr.	Total B.t.u.	Direct Radiation to be Omitted	Condensation Pounds per Hour	Cubic Feet of Air per Minute	Final Temp. Deg. Fahr.	Total B.t.u.	Direct Radiation to be Omitted	Condensation Pounds per Hour
720	600	83	66960	37	69.7	600	88	63360	51	66.0	600	93	59760	66	62.3
	700	78	73920	26	76.0	700	83	69720	43	72.2	700	87	64680	57	67.5
	800	72	78720	7	82.0	800	77	73920	26	77.0	800	82	69120	46	72.0
	900	67	83160	Add 15	86.6	900	72	77250	6	80.5	900	77	72360	30	75.4
724	600	94	74880	68	78.0	600	99	71280	83	74.3	600	104	67680	97	70 5
	700	88	82320	60	85.8	700	93	78120	77	81.4	700	98	73920	94	77.0
	800	83	89280	49	93.0	800	88	84480	68	88.0	800	93	79680	88	83.1
	900	78	95040	34	99.2	900	83	89600	55	93.4	900	88	84240	77	87.8
920	900	81	98280	47	102.5	900	86	92880	68	96.8	900	91	87480	90	91.2
	1000	77	104400	33	109.0	1000	82	98400	56	102.5	1000	87	92400	81	96.3
	1100	73	109560	15	114.6	1100	78	102960	42	107.3	1100	83	96360	68	100.4
	1200	69	113760	Add 8	118.6	1200	74	106000	20	110.5	1200	79	99360	51	103.5
924	900	90	108000	86	112.7	900	95	102600	108	106.9	900	100	97200	129	101.3
	1000	86	115200	76	120.2	1000	91	109200	100	113.7	1000	96	103200	124	107.5
	1100	82	121440	63	126.8	1100	87	114840	89	119.6	1100	92	108240	116	112.8
	1200	78	126720	46	132.2	1200	83	119500	74	124.5	1200	88	112320	103	117.0
1120	1200	79	128160	51	134.0	1200	84	120960	80	126.0	1200	89	113760	109	117.5
	1300	75	132600	31	138.4	1300	80	124800	62	130.0	1300	85	117000	93	122.0
	1400	71	136080	6	142.0	1400	76	127680	40	133.0	1400	81	119280	73	124.8
	1500	67	138600	Add 17	144.5	1500	72	128700	10	134.1	1500	77	120600	50	125.6
1124	1200	87	139680	97	145.8	1200	92	132480	126	138.0	1200	97	125280	155	130.5
	1300	83	145080	91	151 2	1300	88	137280	112	143.0	1300	93	129480	143	134.9
	1400	79	149520	60	156.0	1400	84	141120	94	146.9	1400	89	132720	127	138.5
	1500	75	153000	36	159.5	1500	80	144000	72	150.0	1500	85	135000	108	140.7

PORTABLE UNIT VENTILATORS.

The Univent.

A distinguishing feature of the Univent, manufactured by the Herman Nelson Corporation, Moline, Ill., is the Univent double radiator which is designed to provide the utmost radiating surface in the limited space provided. Another advantage of the double radiator is that it makes possible the use of a mixing damper without any reduction in space, so that temperature control may be obtained, either by hand or automatically, without interfering with the ventilation.

When fresh air is to be used, it is admitted into the upper compartment of the Univent through a window or opening provided in the wall. In this upper compartment is a small electric motor which operates two centrifugal fans. These fans drive the incoming air down the tempering half of the radiator, over a dust-eliminating device located in the bottom compartment, then up through the heating side of the radiator and out through the front of the unit towards the ceiling. The fresh warm air, it is stated, leaves the Univent almost vertically at a velocity oppromixating 1000 ft. per minute, depending upon conditions.

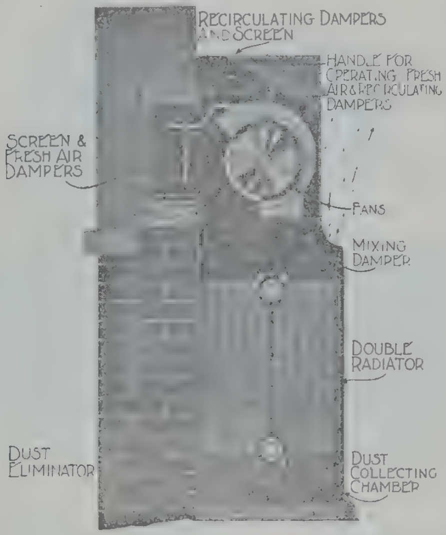

RECIRCULATING DAMPERS AND SCREEN
HANDLE FOR OPERATING FRESH AIR & RECIRCULATING DAMPERS
SCREEN & FRESH AIR DAMPERS
FANS
MIXING DAMPER
DOUBLE RADIATOR
DUST ELIMINATOR
DUST COLLECTING CHAMBER

Fig. 1—Operation of the Univent.

As the fresh air strikes the ceiling its velocity is depended upon to cause its deflection and diffusion throughout the room. The system provides for a vent register or flue, generally placed near the floor on the opposite side of the room, depending upon certain local conditions. The used air passes to the outside of the building, either directly through the flue or through a corridor or attic.

As shown in Fig. 1 a mixing damper is provided above the radiator for mixing the cold and warm air as it leaves the Univent, making it convenient to control the temperature of the air either by hand or automatically. The Univent is also arranged so that the air in the room may be recirculated. This is accomplished by turning the recirculating damper which closes the outdoor inlet and opens the recirculating inlet on top of the unit.

To obtain noiseless operation all the blades of the fans are stamped from a single sheet of copper, aluminum or other non-corroding metal. They are then formed around a pair of rims to which they are brazed. The whole fan, including blades and rims, is made practically in one piece. In addition, the suspension plate, to which the

(Continued on Data Sheet No. 6-E).

PORTABLE UNIT VENTILATORS.

The Univent.

(Continued from Data Sheet No. 6-D).

Univent motor and fans are attached, is independently suspended on the radiator, so that it does not in any way come in contact with the steel cabinet.

Special attention is called by the manufacturer to the location of the vent outlets. Under average conditions one outlet is considered sufficient, but at times several outlets will be found necessary. Vent outlets that are too large, it is found, sometimes interfere with good diffusion. The practice of equipping vent outlets with heat coils or other means for extracting the air is not recommended.

The Univent is regularly furnished with direct-current motors to provide noiseless operation. When alternating current only is available it is recommended that a small motor generator be used to convert the alternating current to direct current.

The Univent is also fitted with a dust eliminator and, if desired, a vapor humidifier can be added. The reservoir at the bottom of the cabinet acts as a dust-collecting chamber. It can be kept filled with water or glycerine to accomplish this purpose.

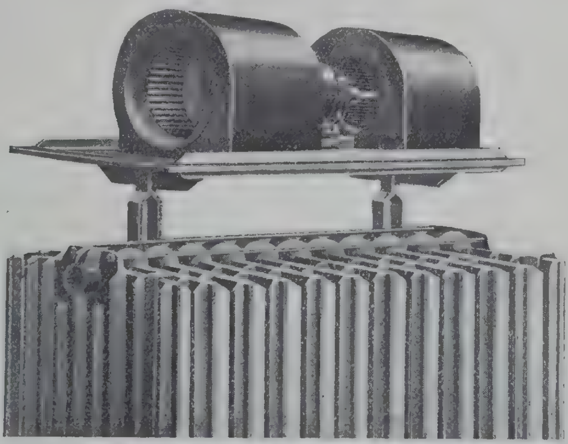


Fig. 2.—Method of Suspending Motor and Fans to Prevent Vibration.

The exact power consumption of the Univents varies with the capacities, but for the wiring calculations and the determination of motor generation sizes, the following table may be used, as it allows a safe working margin:

300 series, 1.5 amperes.
400 series, 2.0 amperes.
500 series, 2.25 amperes.

As stated, the air temperature is controlled by the mixing damper. This damper is arranged to by-pass air from the upper plenum chamber to the cabinet outlet. The arrangement is such that the cold outside air is driven down into the back half of the radiator and tempered before being by-passed.

The figures above the black lines in the accompanying tables are intended to indicate capacities which will insure good diffusion. The first section represents low, the second section, medium, and the third section, high outlet velocity machines.

The figures above the black lines in the accompanying tables are intended to indicate capacities which will insure good diffusion. The first section represents low, the second section, medium, and the third section, high outlet velocity machines.

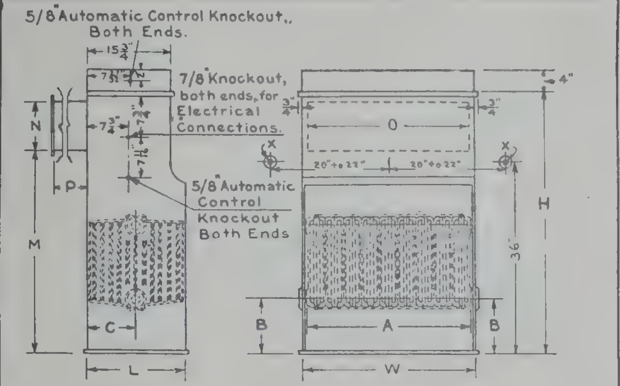
The figures above the black lines in the accompanying tables are intended to indicate capacities which will insure good diffusion. The first section represents low, the second section, medium, and the third section, high outlet velocity machines.

(Continued on Data Sheet No. 6-F).

PORTABLE UNIT VENTILATORS.

The Univent.

(Continued from Data Sheet No. 6-E).


5/8" Automatic Control Knockout, Both Ends.
15 3/4"
7 1/2"
7/8" Knockout, both ends, for Electrical Connections.
N
7 3/4"
P
5/8" Automatic Control Knockout Both Ends
M
C
L
4"
3/4"
3/4"
O
X
X
20" to 22"
20" to 22"
H
36"
B
A
B
W

X = Electrical Outlet, to be provided at one side of machine, left side preferred.

Dimension A is over-all length of radiator.

Dimension B is distance from bottom of Cabinet to center of radiator tappings

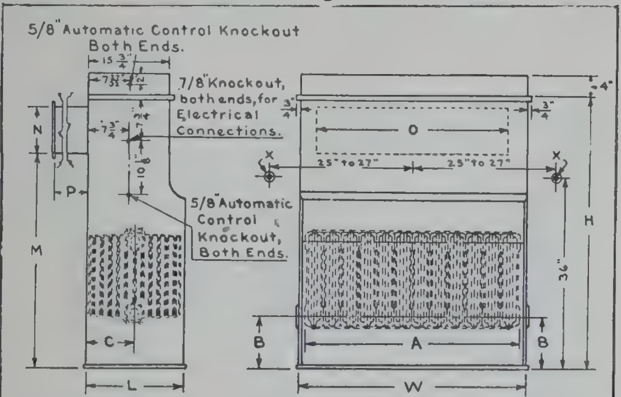
SERIES	RADIATOR					CABINET			INTAKE			
	A	B	C	Steam	Return	H	W	L	M	N	O	P
301	30¾"	14"	9⅛"	1½	1"	49⅛	32¼"	18½"	37 15/16	9 /8	30 /8"	Intake
302	29¾"	"	"	"	"	"	"	"	"	"	"	furnished
303	31¾"	"	"	"	"	"	"	"	"	"	"	12" long at
304	30¾"	11¾"	"	"	"	"	"	"	"	"	"	P Can be
305	29¾"	"	"	"	"	"	"	"	"	"	"	Cut to
306	31¾"	"	"	"	"	"	"	"	"	"	"	not less
307	30¾"	9½"	"	"	"	"	"	"	"	"	"	than 6'
308	29¾"	"	"	"	"	"	"	"	"	"	"	long on
309	31¾"	"	"	"	"	"	"	"	"	"	"	Job
310	30¾"	14"										
311	29¾"	"										
312	31¾"	"										
313	30¾"	11¾"										
314	29¾"	"										
315	31¾"	"										
316	30¾"	9½"										
317	29¾"	"										
318	31¾"	"										
319	30¾"	14"										
320	29¾"	"										
321	31¾"	"										
322	30¾"	11¾"										
323	29¾"	"										
324	31¾"	"										
325	30¾"	9½"										
326	29¾"	"										
327	31¾"	"										

Serial Number	Cubic Feet of Air Per Min.	Capacity in Equivalent Square Feet Direct Steam Radiation and surplus surface for heating, at various entering air temperatures													
		+30°		+10°		0°		-10°		-15°		-20°		-30°	
		Tot. Cap.	Htg. Cap.	Tot Cap	Htg. Cap.	Tot Cap.	Htg. Cap.	Tot. Cap.	Htg. Cap.	Tot. Cap.	Htg. Cap.	Tot. Cap.	Htg. Cap	Tot. Cap.	Htg. Cap.
301	600	142	61	157	36	165	23	173	11	177	4	181	0		
304	600	160	79	177	51	186	45	195	33	199	27	204	21	212	10
302	600	164	83	182	61	191	49	200	38	205	32	209	26	218	15
307	600	177	96	197	74	206	64	216	53	221	48	225	42	235	32
305	600	184	104	204	83	214	73	224	63	229	58	234	52	244	42
303	600	192	113	213	91	223	81	233	71	239	67	244	61	254	51
308	600	203	122	225	103	236	94	247	85	252	80	258	75	269	66
306	600	214	132	236	115	248	106	260	97	266	93	271	89	283	80
309	600	232	152	258	136	270	129	282	121	289	117	295	113	308	105
310	750	170	69	188	36	197	20	206	4	211	0				
313	750	192	91	213	61	223	46	233	31	239	24	244	16	254	0
311	750	195	94	216	64	226	49	236	34	242	27	247	20	258	5
316	750	212	111	235	83	246	70	257	55	263	49	269	42	280	28
314	750	219	118	242	91	254	77	266	64	272	57	278	50	290	37
312	750	227	127	252	100	264	88	276	74	282	68	289	62	301	48
317	750	243	141	269	116	282	104	295	89	302	86	308	80	322	68
315	750	253	152	280	129	294	117	308	106	314	100	322	94	335	83
318	750	277	176	307	156	322	145	337	135	344	130	352	125	367	115
319	900	195	73	216	34	226	14	236	0						
322	900	220	99	244	63	256	44	268	25	274	16	280	7		
320	900	224	102	248	65	260	47	272	28	278	20	284	10	296	0
325	900	245	123	272	89	285	72	298	55	305	46	312	38	324	21
323	900	252	130	278	96	292	80	306	63	312	55	320	46	332	30
321	900	259	138	287	105	301	89	315	73	322	64	329	56	343	40
326	900	279	157	309	126	324	110	339	95	347	88	354	80	369	65
324	900	291	170	322	137	338	126	354	111	362	104	370	96	385	82
327	900	319	198	354	172	371	159	388	146	397	140	405	133	422	119

(Concluded on Data Sheet No. 6-G.)

PORTABLE UNIT VENTILATORS.

The Univent.


5/8" Automatic Control Knockout Both Ends.
15 3/4"
7 3/4"
1/2"
7/8" Knockout, both ends, for Electrical Connections.
N
7 3/4"
10 5/8"
P
M
5/8" Automatic Control Knockout, Both Ends.
C
L
3/4"
3/4"
4"
O
X
X
25" to 27"
25" to 27"
H
36"
B
A
B
W

X = Electrical Outlet, to be provided at one side of machine, left side preferred.

Dimension A is over-all length of radiator.
Dimension B is distance from bottom of Cabinet to center of radiator tappings.

SERIES	RADIATOR					CABINET			INTAKE			
	A	B	C	Steam	Return	H	W	L	M	N	O	P
401	41 1/4"	14 1/2"	9 1/8"	2"	1 1/4"	51 1/2"	42 3/4"	18 1/2"	40 5/16"	9 1/8"	36 1/8"	Intake
402	41 5/8"	"	"	"	"	"	"	"	"	"	"	furnished
403	42"	"	"	"	"	"	"	"	"	"	"	12" long at
404	41 1/4"	12 1/4"	"	"	"	"	"	"	"	"	"	P. Can be
405	41 5/8"	"	"	"	"	"	"	"	"	"	"	cut to
406	42"	"	"	"	"	"	"	"	"	"	"	not less
407	41 1/4"	10"	"	"	"	"	"	"	"	"	"	than 6"
408	41 5/8"	"	"	"	"	"	"	"	"	"	"	long on
409	42"	"										
410	41 1/4"	14 1/2"										
411	41 5/8"	"										
412	42"	"										
413	41 1/4"	12 1/4"										
414	41 5/8"	"										
415	42"	"										
416	41 1/4"	10"										
417	41 5/8"	"										
418	42"	"										
419	41 1/4"	14 1/2"										
420	41 5/8"	"										
421	42"	"										
422	41 1/4"	12 1/4"										
423	41 5/8"	"										
424	42"	"										
425	41 1/4"	10"										
426	41 5/8"	"										
427	42"	"										

Serial Number	Cubic Feet of Air Per Min.	Capacity in Equivalent Square Feet Direct Steam Radiation and surplus surface for heating, at various entering air temperatures													
		+30°		+10°		0°		-10°		-15°		-20°		-30°	
		Tot. Cap.	Htg. Cap.	Tot. Cap.	Htg. Cap.	Tot. Cap.	Htg. Cap.	Tot. Cap.	Htg. Cap.	Tot. Cap.	Htg. Cap.	Tot. Cap.	Htg. Cap.	Tot. Cap.	Htg. Cap.
401	900	[illegible]	85	224	48	235	31	246	12	251	3				
404	900	[illegible]	103	257	79	267	62	279	46	285	37	292	29	304	12
402	900	236	113	262	86	274	70	287	53	293	45	300	37	313	21
407	900	254	137	281	103	295	90	308	74	315	67	322	59	336	44
405	900	264	148	293	118	308	103	322	88	328	81	336	73	350	58
403	900	271	154	300	125	316	111	330	96	337	89	344	82	359	67
408	900	291	174	322	146	338	134	353	103	361	103	369	103	384	93
406	900	301	185	334	158	350	146	366	133	374	126	383	120	399	103
409	900	329	212	364	189	382	178	400	166	408	161	418	155	435	144
410	1050	226	90	251	47	253	25	275	3						
413	1050	258	120	286	81	300	61	314	41	320	31	328	21	341	1
411	1050	265	129	294	90	308	70	322	50	329	40	347	31	352	11
416	1050	286	149	317	112	332	94	348	75	345	66	363	57	379	38
414	1050	298	162	330	120	346	108	362	90	370	81	378	72	396	54
412	1050	304	168	336	132	354	115	370	98	378	89	387	80	402	62
417	1050	328	192	364	159	382	140	400	125	408	119	417	111	435	94
415	1050	338	202	375	170	394	155	412	140	421	131	430	120	448	108
418	1050	372	235	411	207	432	193	452	179	462	172	472	165	492	130
419	1200	251	96	278	45	292	20								
422	1200	285	129	315	81	330	58	346	34	353	23	361	11		
420	1200	293	137	324	91	340	68	356	45	364	33	372	21	387	0
425	1200	316	160	350	116	366	94	383	72	392	61	401	51	418	28
423	1200	329	173	364	131	383	110	400	89	409	79	418	67	437	47
421	1200	335	179	371	137	390	117	407	96	416	86	426	75	444	55
426	1200	363	207	402	168	422	137	441	130	451	120	460	110	480	91
424	1200	275	219	415	181	435	164	455	137	465	135	476	125	497	107
427	1200	411	255	454	221	477	204	498	188	510	137	522	137	543	137

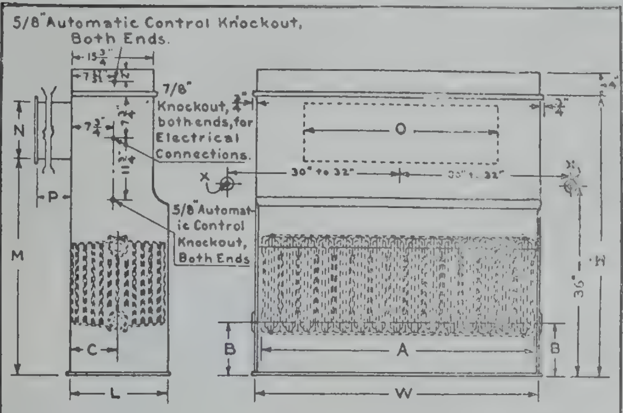
(Concluded on Data Sheet No. 6-H.)

6

PORTABLE UNIT VENTILATORS.

The Univent.

(Continued from Data Sheet No. 6—G)


5/8" Automatic Control Knockout, Both Ends.
15¾"
7⅜"
7/8" Knockout, ¾" both ends, for Electrical Connections.
7¾"
11¼"
N
P
M
5/8" Automatic Control Knockout, Both Ends
C
L
X
30" to 32"
O
¾"
B
A
W
36"
H

X = Electrical Outlet, to be provided at one side of machine, left side preferred.

Dimension A is over-all length of radiator
Dimension B is distance from bottom of Cabinet to center of radiator tappings.

SERIES	RADIATOR					CABINET			INTAKE			
	A	B	C	Steam	Return	H	W	L	M	N	O	P
501	51¾"	14½"	9⅛"	2"	1¼"	53⅛"	53¼"	18½"	39⁹⁄₁₆"	11⅛"	36⅞"	Intake furnished 12" long at P. Can be cut to not less than 6" long on job
502	50¾"	"	"	"	"	"	"	"	"	"	"	
503	52⅜"	"	"	"	"	"	"	"	"	"	"	
504	51¾"	12¼"	"	"	"	"	"	"	"	"	"	
505	50¾"	"	"	"	"	"	"	"	"	"	"	
506	52⅜"	"	"	"	"	"	"	"	"	"	"	
507	51¾"	10"	"	"	"	"	"	"	"	"	"	
508	50¾"	"	"	"	"	"	"	"	"	"	"	
509	52⅜"	"	"	"	"	"	"	"	"	"	"	
510	51¾"	14½"										
511	50¾"	"										
512	52⅜"	"										
513	51¾"	12¼"										
514	50¾"	"										
515	52⅜"	"										
516	51¾"	10"										
517	50¾"	"										
518	52⅜"	"										
519	51¾"	14½"										
520	50¾"	"										
521	52⅜"	"										
522	51¾"	12¼"										
523	50¾"	"										
524	52⅜"	"										
525	51¾"	10"										
526	50¾"	"										
527	52⅜"	"										

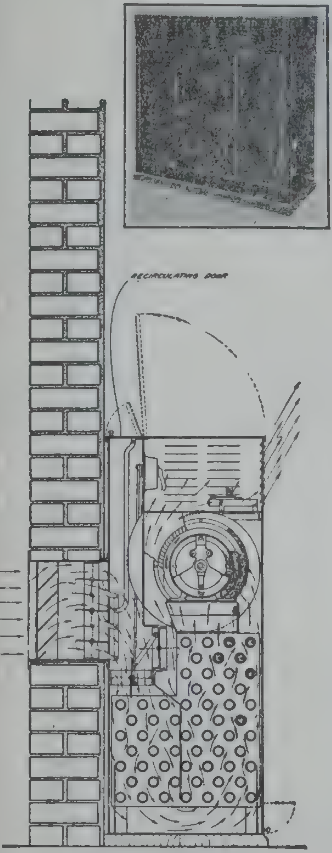
Serial Number	Cubic Feet of Air Per Min.	Capacity in Equivalent Square Feet Direct Steam Radiation and surplus surface for heating, at various entering air temperature													
		+30°		+10°		0°		-10°		-15°		-20°		-30°	
		Tot. Cap.	Htg. Cap.	Tot. Cap.	Htg. Cap.	Tot. Cap.	Htg. Cap.	Tot. Cap.	Htg. Cap.	Tot. Cap.	Htg. Cap.	Tot. Cap.	Htg. Cap.	Tot. Cap.	Htg. Cap.
501	1200	267	111	295	62	310	38	324	13	332	1				
504	1200	301	137	334	100	350	79	366	55	375	44	383	33	399	10
502	1200	308	153	341	107	358	86	374	63	383	52	398	41	407	19
507	1200	333	177	359	135	387	115	406	94	415	84	424	73	441	52
505	1200	345	189	382	148	401	128	419	108	429	93	438	83	457	67
503	1200	355	200	394	160	413	137	432	121	443	112	452	103	471	82
508	1200	380	224	420	187	441	168	462	137	472	137	482	132	503	113
506	1200	396	241	438	205	460	188	482	170	493	162	503	137	525	135
509	1200	433	277	478	245	503	230	526	215	538	207	550	199	573	184
510	1350	291	116	322	60	338	32	354	4						
513	1350	329	154	365	102	383	76	400	50	409	37	419	25	437	0
511	1350	336	161	372	109	390	84	408	58	417	45	427	32	455	7
516	1350	365	189	405	142	425	118	444	94	454	82	465	71	484	46
514	1350	377	202	418	154	438	132	459	108	470	97	480	85	500	62
512	1350	388	213	430	167	451	145	472	122	482	110	493	99	514	76
517	1350	416	240	461	197	483	154	505	154	517	144	528	135	550	113
515	1350	433	258	479	216	503	197	526	176	538	154	551	154	573	136
518	1350	475	300	525	262	552	245	577	227	590	218	603	209	628	154
519	1500	314	120	348	56	366	25								
522	1500	356	161	394	102	413	72	432	43	442	28	451	14		
520	1500	362	167	400	109	421	80	440	51	450	36	460	22		
525	1500	394	171	437	145	458	118	479	90	490	76	501	63	522	35
523	1500	407	213	452	160	474	134	497	107	507	94	519	81	541	54
521	1500	418	224	464	171	487	146	509	120	520	107	532	94	555	69
526	1500	450	255	498	206	523	171	547	158	559	146	572	134	595	110
524	1500	468	274	518	226	543	203	568	171	581	168	594	157	620	134
527	1500	513	318	567	276	596	256	623	234	638	171	652	171	678	171

PORTABLE UNIT VENTILATORS

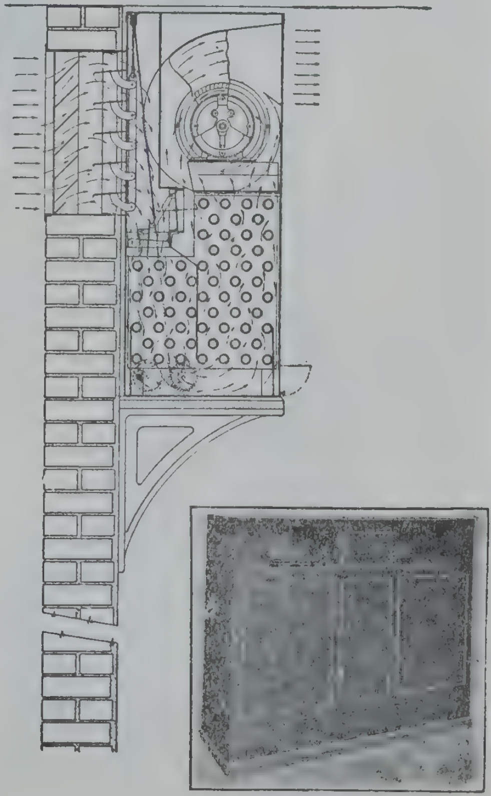
The Heatovent

Characteristic features of the Heatovent, manufactured by the Buckeye Blower Co., Columbus, O., are its two low-speed multiblade fans, its special steam pipe-coil radiator and the novel design of its steel cabinet. The fan wheels are mounted directly on opposite ends of the motor shaft. Air is drawn in from out-of-doors, or may be recirculated, if desired. It passes through the pipe-coil heater and is then discharged from the cabinet into the room through small louvre openings at the top of the cabinet and across the front and ends. The final temperature of the air is regulated by a balanced mixing damper in the air intake which directs all or part of the air through the heater, allowing the balance to by-pass directly to the fans. Uniform final temperature of the air leaving the cabinet is obtained by the mixing of the cold and warm air in the fans.

Each Heatovent is provided with a slow-speed 40° C. electric motor, mounted on an insulated base on top of the heater structure. A multiblade fan wheel is keyed to each end of the motor shaft. By this means all rotating parts are mounted entirely independent of the casing. This is done to prevent any magnetic hum from being transmitted through the casing. Care is also taken to secure dynamic balance so as to prevent vibration. Standard motors are wound for 115 volts, direct current. A motor rheostat is used to regulate the speed of the fans.



Type C Heatovent.



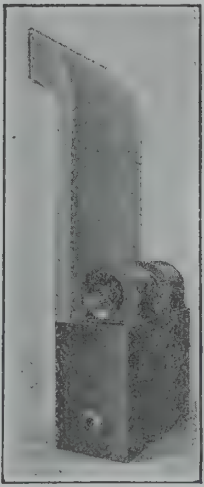
Type D Heatovent.

(*Continued on Data Sheet No. 6-J*)

PORTABLE UNIT VENTILATORS

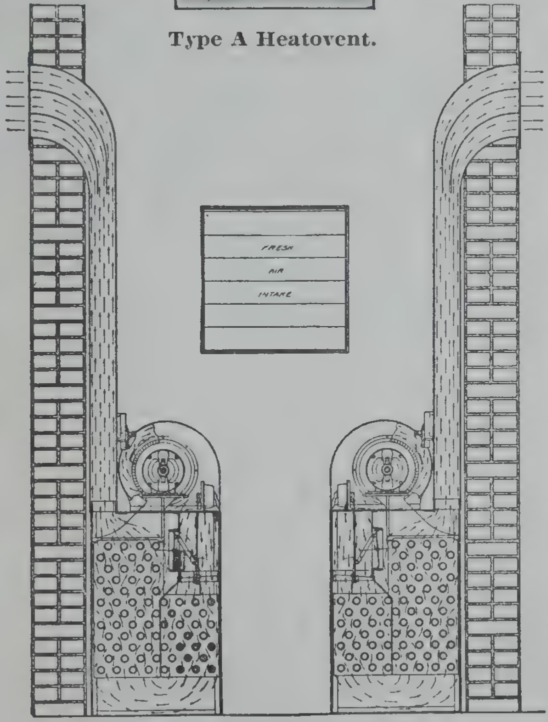
The Heatovent

(*Continued from Data Sheet No. 6-I*)

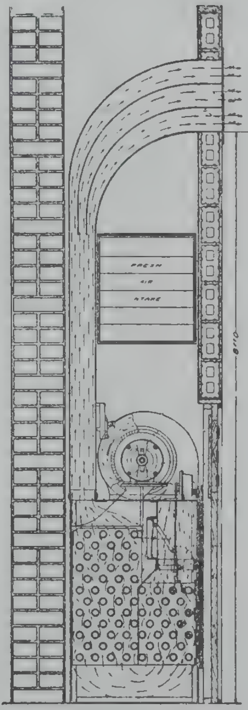


Type A Heatovent.

Type B Heatovent.



Type A Heatovent.



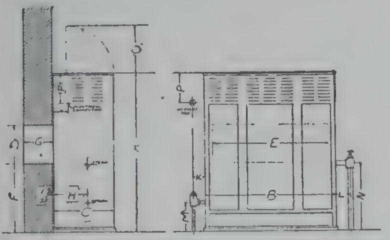
Type B Heatovent.

(*Continued on Data Sheet No. 6-K*)

PORTABLE UNIT VENTILATORS

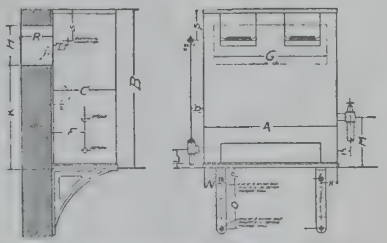
The Heatovent

(Continued from Data Sheet No. 6-J)



Unit No	A	B	C	D	E	F	G	H	K	L	M	N	O	P	R	Steam	Return
36C	49⅜	32	18⅝	9"	24	21" is minimum 34" is maximum	Varies according to width of Wall [illegible] minimum	10½	1⅜	4½	4⅛	21	14½	12	5	1¼"	[illegible]
37C	49⅜	32	18⅝	9"	24			10½	1⅜	4½	5½	21	14½	12	5	1¼"	1"
46C	49⅜	40	18⅝	9"	12			10½	1⅜	4½	3¼	21	14½	12	5	1¼"	1"
47C	49⅜	40	18⅝	9"	12			10½	1⅜	4½	5¼	21	14½	12	5	1¼"	[illegible]
56C	49⅜	50	18⅝	12	10			10½	3⅜	4½	4⅛	21	14½	12	5	2"	1¼"
57C	49⅜	50	18⅝	12	10			10½	3⅜	4½	5⅜	21	14½	12	5	2"	1¼"
66C	49⅜	60	18⅝	12	[illegible]			10½	3⅜	4½	3⅛	21	14½	12	5	2"	1¼
67C	49⅜	60	18⅝	12	10			10½	3⅜	4½	5⅜	21	14½	12	5	2	1¼

DIMENSIONS OF TYPE C SERIES



Un. No	A	B	C	D	E	F	G	H	K	L	M	N	O	P	R	S	T	Steam	Return
36D	32	42	18⅝	3¾	4½	10½	24	9	[illegible] minimum [illegible] maximum	5½	17¾	5	15	3½	Varies according to width of wall [illegible] is minimum	12	5	1¼	1"
37D	32	45¾	18⅝	3¾	4½	10½	[illegible]	9		5½	21	5	15	3½		12	5	1¼"	1"
38D	32	49½	18⅝	3¾	4½	10½	24	9		5½	24¾	5	15	3½		12	5	1¼"	1
46D	40	42	18⅝	3¾	4½	10½	[illegible]	9		5½	17¾	5	15	3½		12	5	1¼"	1"
47D	40	45¾	18⅝	3¾	4½	10½	32	9		5½	21	5	15	3½		12	5	1¼"	1"
48D	40	49½	18⅝	3¾	4½	10½	[illegible]	9		5½	24¾	5	15	3½		12	5	1¼	1"
56D	50	42	18⅝	3¾	4½	10½	30	12		5½	17¾	5	15	3½		12	5	2"	1¼
57D	[illegible]	45¾	[illegible]	3¾	4½	10½	30	12		5½	21	5	15	3½		12	5	2"	1¼"
58D	[illegible]	49½	[illegible]	3¾	4½	10½	30	12		5½	24¾	5	15	3½		12	5	2"	1¼"
66D	60	42	18⅝	3¾	4½	10½	36	12		5½	17¾	5	15	3½		12	5	2"	1¼"
67D	[illegible]	45¾	18⅝	3¾	4½	10½	36	12		5½	21	5	15	3½		12	5	2"	1¼"
68D	60	49½	18⅝	3¾	4½	10½	36	12		5½	24¾	5	15	3½		12	5	2"	1¼"

DIMENSIONS OF TYPE D SERIES

Room Temperature 70 degrees Fahr — Steam at Zero pounds gauge pressure.

		Entering Air -10 F			Entering Air Zero F			Entering Air +10 F			Entering Air +20 F		
Unit No	Cu Ft Air per min	Final Temp	Cond lbs per hour	Omit Sq Ft Rad	Final Temp	Cond lbs per hour	Omit Sq Ft Rad	Final Temp	Cond lbs per hour	Omit Sq Ft Rad	Final Temp	Cond lbs per hour	Omit Sq Ft Rad
36	750	68	76	Add 6	73	70	10	78	64	26	84	59	44
37		82	[illegible]	Omit 38	88	84	56	91	76	66	96	70	81
38*		94	101	" 75	98	94	85	102	86	100	106	78	114
46	1000	68	102	Add 8	73	93	13	78	85	34	84	78	59
47		82	120	Omit 50	88	112	75	91	101	83	96	93	108
48*		94	135	" 100	98	125	114	102	115	134	106	105	152
50	1250	68	127	Add 10	73	116	16	78	106	42	84	98	74
57		82	150	Omit 63	88	140	94	91	126	110	96	116	135
58*		94	169	" 125	98	156	142	102	144	167	106	131	190
66	1500	68	153	Add 12	73	140	20	78	128	53	84	118	89
67		82	160	Omit 75	88	168	112	91	152	132	96	140	162
68*		94	202	" 150	98	188	170	102	172	201	106	158	228

* Type D Heatovents only.

Room Temperature 70 degrees Fahr — Steam at five pounds gauge pressure.

		Entering Air -10 F			Entering Air Zero F			Entering Air +10 F			Entering Air +20 F		
Unit No	Cu Ft. air per min	Final Temp	Cond lbs per hour	Omit Sq Ft Rad	Final Temp	Cond lbs per hour	Omit Sq Ft Rad	Final Temp	Cond lbs per hour	Omit Sq Ft Rad	Final Temp	Cond lbs per hour	Omit Sq Ft Rad
36	750	74	82	13	80	77	31	85	71	47	90	65	63
37		90	97	63	95	91	78	99	84	92	104	77	106
38*		104	111	106	107	101	117	111	95	132	115	87	142
46	1000	74	110	17	80	102	42	85	94	63	90	86	84
47		90	130	84	95	121	104	99	112	122	104	103	142
48*		104	148	142	107	135	156	111	126	176	115	116	190
56	1250	74	138	21	80	129	52	85	118	78	90	108	105
57		90	163	105	95	152	130	99	140	152	104	129	177
58*		104	185	177	107	169	195	111	158	220	115	145	237
66	1500	74	156	25	80	153	63	85	141	94	90	129	126
67		90	195	126	95	182	156	99	168	182	104	155	198
68*		104	222	213	107	203	234	111	189	264	115	174	285

*Type D Heatovents only

Engineering Data on Types C and D Heatovent.

(Concluded on Data Sheet No. 6-L)

PORTABLE UNIT VENTILATORS

The Heatovent

(Concluded from Data Sheet No. 6-K)

Uniformity in size, shape and in the position of the fans in the wheels is secured through the process of manufacture, by which the fan wheels are die-formed and held in a jig as they are welded into the wheel. Each half wheel is formed separately and mounted on the central aluminum disc, as it was found that these short half-length blades make a stronger and more rigid wheel than one continuous blade.

No. 12 and No. 14 gauge stretcher leveled furniture steel is used in the construction of the Heatovent cabinet. Four types are regularly made, Type C being designed for installation directly in the room to be ventilated; Type D for basement wall installation at the ceiling line to keep the radiator as high above the water-line of the boiler as possible, discharging the air horizontally across the ceiling; Type A designed to be built in a space adjacent to the room to be ventilated with the access door or panel in the rear; and Type B, to be built in a niche in the wall within the room to be ventilated with access door or panel in the front. As a general rule, each unit is used in connection with direct radiation for heating. Type A is described as especially adaptable for old school buildings which were designed with a common wardrobe between two classrooms. In such cases the outer end of the wardrobe is partitioned off and provided with an outside fresh-air intake. A Heatovent for each room is then installed in this space. Both Types A and B introduce the fresh warm air into the room through a heat register placed 8 ft. above the floor line at a temperature above 70° F. and with a velocity of 300 ft. per minute. This arrangement complies with the laws in effect in some states requiring fresh air admission at that level.

ENGINEERING DATA ON TYPES A AND B HEATOVENT

Room Temperature 70 degrees Fahr — Steam at Zero pounds gauge pressure

		Entering Air -10 F			Entering Air Zero F			Entering Air +10 F			Entering Air +20 F		
Unit No	Cu Ft air per min	Final Temp	Cond lbs per hour	Omit Sq Ft Rad	Final Temp	Cond lbs per hour	Omit Sq Ft Rad	Final Temp	Cond lbs per hour	Omit Sq Ft Rad	Final Temp	Cond lbs per hour	Omit Sq Ft Rad
31	900	68	94	Add 8	73	84	11	78	77	30	84	70	53
32		82	108	Omit 45	88	101	68	91	91	80	96	84	97
33		94	122	.. 90	98	113	106	102	103	120	106	95	136
34		104	133	.. 128	107	122	140	112	114	162	115	104	171
35		113	144	.. 165	116	133	174	121	124	193	123	112	200
41	1200	68	122	Add 10	73	112	15	78	102	40	84	94	71
42		82	144	Omit 60	88	134	90	91	128	103	96	112	130
43		94	162	.. 120	98	150	142	102	138	161	106	126	182
44		104	173	.. 171	107	164	188	112	152	216	115	139	228
45		113	192	.. 219	116	177	233	121	166	256	123	150	207
51	1500	68	153	Add 12	73	140	19	78	128	50	84	118	89
52		82	180	Omit 75	88	168	113	91	152	133	96	140	162
53		94	202	.. 150	98	188	177	102	172	201	106	158	236
54		104	222	.. 214	107	204	234	112	190	270	115	174	285
55		113	240	.. 275	116	222	290	121	207	320	123	187	332
61	1800	68	188	Add 15	73	168	23	78	153	60	84	140	112
62		82	216	Omit 90	88	202	136	91	182	159	96	168	196
63		94	245	.. 180	98	225	213	102	207	241	106	189	284
64		104	268	.. 257	107	245	281	112	228	324	115	208	342
65		113	288	.. 331	116	266	348	121	248	385	123	225	400

Room Temperature 70 degrees Fahr. Steam at 5 pounds gauge pressure

Unit No.	Cu Ft. Air per min.	Final Temp.	Cond lbs per hour	Omit Sq. Ft. Rad.	Final Temp.	Cond. lbs per hour	Omit Sq. Ft. Rad.	Final Temp.	Cond lbs per hour	Omit Sq Ft. Rad	Final Temp.	Cond lbs per hour	Omit Sq Ft. Rad
31	900	74	100	15	80	92	38	85	85	57	90	77	75
32		90	117	76	95	109	93	99	101	110	104	93	128
33		104	133	128	107	122	140	111	114	158	115	104	171
34		115	146	171	118	135	182	121	124	192	125	116	208
35		125	158	208	128	147	219						
41	1200	74	132	20	80	122	50	85	113	75	90	103	101
42		90	156	100	95	145	125	99	134	146	104	124	170
43		104	178	170	107	162	187	111	152	210	115	140	228
44		115	196	228	118	180	241	121	166	256	125	154	276
45		125	211	276	128	196	291						
51	1500	74	156	25	80	153	63	85	141	94	90	129	126
52		90	195	126	95	182	156	99	168	182	104	155	198
53		104	222	213	107	203	234	111	189	264	115	174	285
54		115	245	235	118	225	302	121	207	320	125	192	347
55		125	265	346	128	245	365						
61	1800	74	198	30	80	184	76	85	170	113	90	155	151
62		90	235	150	95	219	187	99	202	220	104	186	255
63		104	267	255	107	244	280	111	227	317	115	200	342
64		115	294	342	118	270	364	121	250	385	125	231	415
65		125	317	415	128	294	438	...					

VENTILATION.

Ventilation consists briefly of all the artificial air conditioning necessary to maintain the air inside of a building in a condition desirable for certain purposes (either for breathing or to suit given manufacturing processes) and at such standards as may be regarded as desirable...

The most common form of ventilation is that used to furnish an air supply (and sometimes an air exhaust) for the occupants of a building (without which the interior air would become foul) and also for the purpose of removing objectionable odors—such as in kitchens, restaurants and toilet rooms.

In past years the amount of carbonic acid in the air has been used to determine the comparative degree of purity even though it has been understood that carbonic acid itself is not dangerous. This is because pure air seldom contains over 4 parts in 10,000, while in air used for breathing purposes the number of parts rises rapidly and almost proportionately with the other impurities contained in exhaled air. Therefore, a statement of the amount of carbonic acid present in a given sample of air—a measurement comparatively easy to make—may be taken as indicative of the amount of other impurities also.

Each person gives off about 0.6 cu. ft. of carbonic acid per hour. If the fresh air entering a room has 4 parts in 10,000 of carbonic acid and the limit in the room is desired to be kept below a certain number of parts the number of cubic feet per minute per occupant must be not less than as follows:

Limit of Parts of Carbonic Acid in 10,000 Parts of Air	Cubic Feet of Fresh Air Necessary per Minute Per Occupant.
5	133
6	67
7	44
8	33
9	27
10	22
11	19
12	17

While these are the theoretical amounts of air required, some consideration must be shown for the quantity of air contained in the room at the beginning of its occupancy and also the length of time the room is occupied. Thus, a church where the services are short and the volume of fresh air large at the beginning requires less air to ventilate than a moving picture theater running continuously for ten hours a day and usually in more or less cramped quarters.

Sheets Nos. 6-A to 6-E inclusive give the recommended number of air changes for various rooms in different types of buildings.

EXHALED AIR AND DIFFUSED BODY HEAT.

The following table gives the composition of pure air and of respired air:

	PURE AIR	RESPIRED AIR
Oxygen	20.35	16.2
Nitrogen	78.10	75.4
Carbon Dioxide	0.30 to 0.04	3.4
Water Vapor	1.5 (variable)	5.

As the respired air is immediately diffused in the air of the room, it cannot be directly removed, but only diluted till it ceases to be harmful. There is, therefore, no definite standard of purity, and any line drawn between good and poor ventilation is arbitrary. Pure air contans 3 to 4 parts of carbon dioxide in 10,000. With an increase to 11 parts in 10,000, the air becomes noticeably oppressive, while an increase of 3 parts or a total of 6 to 7 parts is scarcely noticeable.

The physical principles involved in heating buildings are much more complex than is usually supposed, and exhibit an admirable nicety in the balancing of forces. We have first of all to consider the heat generated by the human body, and the method of its disposal, which are important conditions determining the most desirable room temperatures, and in densely peopled buildings, largely determining the result of vital processes dependent in part upon the activity of the individual.

The following shows the amount of bodily heat diffused:

	B. T. U. PER HOUR
Child six years old	240
Adult at rest	380
Adult at work	500
Man 30 years old in an atmosphere with a temperature 68° F	440
The same, in atmosphere of 31° F	600
Woman 32 years old	480
Adult in old age	360

The amount of heat in B. T. U. usually assumed as given off per person per hour in an atmosphere of 70° F. is 400 for adults and 200 for children. These are the figures generally used when the heating effect of the occupants of assembly halls or auditoriums is taken into account.

(BUFFALO FORGE Co.)

VENTILATION

Air Required to Dilute Automobile Exhaust Gases to Safe Proportions in Air Breathed

(Car tested under summer conditions unless otherwise stated)

Number of Cars Tested	Type of Car[1]	Speed, miles per hour	Average carbon monoxide in exhaust gas		Cu. ft. per min. of ventilating air per car required to dilute carbon monoxide to 1 part per 10,000 (safe for indefinite period)
			Per cent	Cu. ft. per hr., per car (at 65° fahr., 29.92" Hg)	
Engine Idling					
5	5P	Car standing	7.3	39.2	6533
7[2]	7P	"	6.3	35.3	5883
5[2]	1½T	"	7.1	31.0	5167
4	1½-3	"	2.4[3]	13.2[3]	2200[3]
3	3½-4½	"	8.8	66.4	11070
6	5T	"	6.8	50.5	8417
Engine Racing					
5	5P	standing	7.1	76.9	12820
7[2]	7P	"	7.8	137.0	22830
5[2]	1½T	"	7.7	67.9	11320
4	1½-3	"	4.7	55.8	9300
3	3½-4⅓	"	8.6	158.2	26370
6	5T	"	7.5	105.2	17530
Average Load and Level Grade					
11[2]	5P	3	6.7	36.3	6050
7[2]	7P	3	6.6	53.1	8850
5[2]	1½T	3	7.8	47.4	7900
22	1½-3	6	7.3	67.6	11270
16	3½-4½	6	7.8	92.6	15430
18	5T	6	7.5	110.3	18380
9	5P	10	7.8	44.1	7350
6	7P	10	8.3	75.5	12580
7	1½T	10	7.6	58.7	9783
20	1½-3	10	7.5	104.0	17330
13	3½-4½	10	7.5	147.6	24600
12	5T	10	6.9	151.6	25270
9	5P	15	6.8	57.9	9650
6	7P	15	8.6	111 8	18630
7	1½T	15	6.7	77.2	12870
15	1½-3	15	6.2	103.9	17320
5	3½-4½	15	4.8	131.2	21870
Full Load and 3% Grade Upward					
7[2]	7P	3	8.4	88.5	14750
5[2]	1½T	3	9.5	65.1	10850
22	1½-3	6	6.9	114 3	19050
16	3½-4⅓	6	6.9	148.1	24680
18	5T	6	6.1	163.3	27220
6	7P	10	8.9	117.2	19530
7	1½T	10	7.3	86.3	14380
22	1½-3	10	6.7	149.6	24930
16	3½-4½	10	6.1	88.5	14750
18	5T	10	4.9	199.3	33220
13	7P	15	8.3	146.7	24450
12	1½T	15	6.9	117.7	19620
15	1½-3	15	5.4	130.1	21680
16	3½-4½	15	4.1	181.7	30280
Accelerating up 3% Grade with Full Load					
7[2]	7P	0 to 15	6.5	163.6	27270
5[2]	1½T	0 to 15	5.4	65.9	10980

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[1] Types are designated thus: 5P and 7P represent 5 and 7 passenger cars, 1½T, 1½-3, 3½-4½ and 5T represent trucks of the respective tonnages.

[2] Tested under winter conditions.

[3] These averages are undoubtedly too low to represent correctly the type of trucks. All cars were tested with carburetors set as submitted by the car owners. These four happened to be set for lean mixtures.

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AIR CHANGES.

Churches and Theatres.

The table below shows the changes of air per hour, or the cubic feet per minute (C. F. M.) per occupant, recommended for various rooms in theatres, churches, moving picture halls, assembly halls, and other places of congregation.

Room	SUPPLY		EXHAUST	
	C. F. M. Per Occupant.	Minimum No. of Air Changes.	C. F. M. Per Occupant.	Minimum No. of Air Changes.
Churches				
Auditorium	20	...	20	...
Banquet	30	8	30	8
Coat and Locker	none	...	...	...
Sunday School	30	...	30	...
Social Rooms	30	8	30	8
Toilets	...	none	none	8 to 10
Theatres				
Auditorium	30	...	30	...
Lobbies	...	10	...	...
Retiring Rooms	...	4	...	4
Smoking Rooms	...	6	...	10 to 12
Toilets	...	none	...	8 to 10

AIR CHANGES.

Hospitals.

The table below shows the changes of air per hour, or the cubic feet per minute (C. F.M.) per occupant, recommended for various rooms in hospitals, sanitariums, private hospitals in other buildings, and similar apartments used for medical purposes.

HOSPITALS

ROOM	SUPPLY		EXHAUST	
	C.F.M per Occupant.	Minimum Air Changes Per Hour.	C.F.M. Per Occupant.	Minimum Air Changes Per Hour.
Anesthesia	..	8 (with local control)	..	12
Autopsy	..	4	..	8 to 10
Bakery	..	none	..	10
Baths, Toilets, etc.	..	none	..	12
Boiler (large)	..	10	..	none
Clothes Storage	..	none	..	6
Dairy, Meats, etc.	..	none	..	8
Dark	..	4	..	6
Delivery	60	8	60	8
Dining	20	6	30	8
Doctors Wash	..	none	..	8
Dressing	..	none	..	6
Drying Closets	..	none	..	20
Electrotherapeutic	..	6	..	8
Engine	..	4 to 6	..	8 to 10
Examination	..	6	..	6
Gymnasium	30	8	30	8
Hydrotherapeutic	..	6	..	8
Ice Making	..	none	..	4 to 6
Instrument (Prep.)	..	none	..	6
Isolation	30 to 60	6	30 to 60	6
Kitchens	..	6 to 8	..	15
Laboratories	..	6	..	8 to 10
Laundry (Small)	..	none	..	10
Laundry (Large)	..	6 to 8	..	12
Lockers	..	none	..	6 to 10
Machinery	..	4 to 6	..	8 to 10
Marking and Sewing	..	none	..	6
Meats, Dairy etc.	..	none	..	8
Operating	100	10	100	10 (See Note A)
Pantries (Serving)	..	none	..	12
Plaster	..	4	..	6
Preparation (Inst.)	..	none	..	6
Pus Dressing	..	5	..	8
Pump and Refrigeration	..	4 to 6	..	8 to 10
Recovery	..	8	..	8
Refrigeration and Pump	..	4 to 6	..	8 to 10
Serving Pantries	..	none	..	12
Sewing and Marking	..	none	..	6
Shops, etc.	..	none	..	6
Solarium	..	4	..	4
Slop Sink Closets	..	none	..	12
Sterilizing Room	..	8	..	12
Stores	..	none	..	4
Toilets, Baths, etc.	..	..	..	12
Utility	..	none	..	12
Waiting	30	6	30	6
Wards (Gen'l)	30 to 60	6	30 to 60	6
Wards (Contagious)	100	10	100	10
Wash (Doctors)	..	none	..	8

Note A—Operating Rooms should have auxiliary top outlet in exhaust system.

AIR CHANGES.

Hotels and Libraries.

The table below shows the changes of air per hour, or the cubic feet per minute (C. F. M.) per occupant, as recommended by the best authorities, for various rooms in hotels and their various service departments and in libraries.

HOTELS

ROOM	SUPPLY		EXHAUST	
	C.F.M. Per Occupant	Minimum Air Changes Per Hour	C.F.M. Per Occupant	Minimum Air Changes Per Hour
Ball Rooms	30	8	30	8
Banquet Hall	30	8	30	8
Bathroom (Private)	..	none	..	10
Boiler Room (Large)	..	10	..	none
Dining	30	8	30	8
Engine, Large	..	4 to 6	..	8 to 10
Kitchen	..	6 to 8	..	15
Laundry	..	6 to 8	..	12
Locker Room	..	none	..	10
Pump Room (Large)	..	4 to 6	..	8 to 10
Sleeping	..	none	..	note—see note "A'
Toilets (Main)	..	none	..	12
Toilets (Private)	..	none	..	10
LIBRARIES				
Administration Center	..	6	..	6
Book Rooms	30	6	30	6
Galleries, Public	..	4	..	4
Galleries, Picture	..	4	..	4
Lecture Rooms	30	8	30	8
Locker Rooms	..	none	..	10
Lobbies—Large Bldg.	..	8	..	none
Museums	..	4	..	4
Reading Rooms	30	6	30	6
Stack Room	..	none	..	4
Toilet Rooms	..	none	..	10

Note A—Sleeping rooms with connecting baths can be ventilated through the bath.

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AIR CHANGES.

Schools.

This table shows the changes of air per hour or the cubic feet (C. F. M.) per minute per occupant, as recommended by the best authorities, for various rooms in schools, institutes, colleges, universities, and other educational buildings.

SCHOOLS

ROOM	SUPPLY		EXHAUST	
	C. F. M. Per Occupant	Minimum Air Changes Per Hour	C. F. M. Per Occupant	Minimum Air Changes Per Hour
Auditorium	20 to 30	8	30	8
Board	..	6	..	6
Chemical Lab.	30	6	30	6
Chemical Cabinets	none	none	100 per cabinet	..
Glass	30	6	30	6
Coat	none	none	..	8
Commercial	30	6	30	6
Corridors	..	See Note A	..	..
Domestic Science	30	6	40	8
Drawing	30	6	30	6
Dress Making	30	6	30	6
Forge Shop	See Note B	..	..	See Note B
Forges	200 c. f. m. per forge		400 c. f. m. per forge	
Gymnasium	30	8	30	8
Kitchen for Lunch Room	..	6 to 8	..	12
Kitchen for Cooking Class	30	6	50	10
Kitchen (Model)	..	6	..	8
Lecture	30	8	30	8
Library	30	7	30	7
Locker	none	none	..	10
Lunch	..	6	..	10
Machine Shop	30	6	30	6
Model Apart	..	4 to 6	..	4 to 6
Office—General	..	6	..	6
Office—Private	none	none	none	none
Physical Lab.	30	6	30	6
Recitation	30	6	30	6
Shower Baths	none	none	..	10
Swimming Pool	..	4	..	10
Toilets	none	none	..	10 to 12
Wardrobes	none	none	..	8
Wood working	30	6	40	8

Note A—Air supply to corridors should be 4 changes per hour or enough additional to be sufficient to counterbalance the excess of exhaust from all rooms connected to corridors where there is no air supply or where the supply is less than the exhaust.

Note B—The air supply to a forge room should be not less than 30 c. f. m. per occupant and should be increased to make up any unbalanced condition occurring when the forges are all running each being supplied with 200 c. f. m. air blast and 400 c. f. m. forge exhaust.

AIR CHANGES.

Miscellaneous.

The table below shows the changes of air per hour, or the cubic feet per minute (C. F. M.) per occupant, as recommended by the best authorities for various rooms of miscellaneous character as listed below.

ROOM	SUPPLY		EXHAUST	
	C. F. M. Per Occupant	Minimum Air Changes Per Hour	C. F. M. Per Occupant	Minimum Air Changes Per Hour
Assembly and Convention Halls	30	8	30	8
Boiler Rooms	..	10	..	none
Engine Rooms	..	4 to 6	..	8 to 10
Factories	20 to 30	4	20 to 30	4
Foundaries	..	4	..	4
Halls and Assemblies	30	8	30	8
Mill Buildings	20 to 30	4	20 to 30	4
Offices (outside small)	none	..	none	..
Offices (inside small)	..	6	..	6
Offices (large)	20 to 30	..	20 to 30	..
Private Office (large)	..	6	..	6
Private Office (small)	..	none	..	none
Public Offices (large)	..	4 to 8	..	4 to 8
Public Offices (inside small)	..	6	..	6
Public Offices (outside small)	..	none	..	none
Public Toilet Rooms	..	none	..	10
Public Waiting Rooms	..	4 to 6	..	4 to 6
Pump Rooms	..	4 to 6	..	8 to 10
Round Houses	..	none	..	12
Toilets	..	4 to 6	..	10
Waiting Rooms	none	..	..	4 to 6

PROPERTIES OF AIR

Temperature Degrees F	Vol. of Dry Air with Unity at 32 F.	Cubic Feet in 1 lb. of Air	Weigh of 1 cu. ft. of Dry Air	Elastic Force of Vapor in. of Mercury	Feet of Vapor from 1 lb. of Water	B. T. U. Absorbed by 1 cu. ft. of Air per Deg. F		Cu. Ft. of Air Raised 1 Deg. F. by 1 B. T. U.	
						Dry Air	Sat. Air	Dry Air	Sat. Air
Zero	0.935	11.58	0.0864	0.044	......	0.02056	0.02054	48.5	48.7
12	0.960	11.87	0.0842	0.074	......	0,02004	0.02006	50.1	50.0
22	0.980	12.14	0.0824	0.118	......	0.01961	0.01963	51.1	51.0
32	1.000	12.40	0.0807	0.181	3289	0.01921	0.01924	52.0	51.8
42	1.020	12.64	0.0791	0.267	2252	0.01882	0.01884	53.2	52.8
52	1.041	12.88	0.0776	0.388	1595	0.01847	0.01848	54.0	53.8
60	1.057	123.9	0.0764	0.522	1227	0.01818	0.01822	55.0	54.6
62	1.061	13.13	0.0761	0.556	1135	0.01811	0,01812	55.2	54.7
70	1.078	13.34	0.0750	0.754	882	0.01777	0.01794	56.3	55.5
72	1.082	13.39	0.0747	0.785	819	0.01767	0.01790	56.5	55.8
82	1.102	13.64	0.0733	1.092	600	0.01744	0.01770	57.2	56.5
92	1.122	13.90	0.0720	1.501	444	0.01710	0.01751	58.5	57.1
100	1.139	13.95	0.0710	1.929	356	0.01690	0.01735	59.1	57.8
102	1.143	14.14	0.0707	2.036	334	0.01682	0.01731	59.5	57.8
112	1.163	14.40	0.0694	2.731	253	0.01651	0.01711	60.6	58.5
122	1.184	14.65	0.0682	3.621	194	0.01623	0.01691	61.7	59.1
132	1.204	14.90	0.0671	4.752	151	0.01596	0.01670	62.5	59.9
142	1.224	15.15	0.0660	6.165	118	0.01571	0.01652	63.7	60.6
152	1.245	15.40	0.0649	7.930	93.3	0.01544	0.01634	65.0	61.5
162	1.265	15.65	0.0638	10.099	74.5	0.01518	0.01616	66.2	62.4
172	1.285	15.90	0.0628	12.758	59.2	0.01494	0.01598	67.1	63.3
182	1.306	16.17	0.0618	15.960	48.6	0.01471	0.01580	68.0	64.2
192	1.326	16.42	0.0609	19.828	39.8	0.01449	....	68.9	......
202	1.347	16.67	0.0600	24.450	32.7	0.01426	....	69.5	......
212	1.367	16.92	0.0591	29.921	27.1	0.01406	....	71.4	......

MEASUREMENT OF AIR FLOW

The quantity and velocity of air discharged by a fan or flowing through a pipe may be determined by an anemometer, and orifice, a short length of pipe, a converging nozzle, or a Pitot tube.

The anemometer is used in many cases where extreme accuracy is not required or where the velocity of the air is low, and is especially adaptable to measuring air entering a room through a register or duct. The reading should be taken in the manner described on Standard Data Sheet No. 10-B. An anemometer should be frequently calibrated, as hot air will quickly dry up the bearings, and the readings will be affected as much as 10%. This instrument may also vary at high velocities.

Air may be measured by discharging into a large air-tight chamber, which can be easily provided for permanent testing work, from which the air escapes through cylindrical or conical orifices. The pressure in the chamber is recorded by a pressure gauge and the quantity of air delivered can be computed, using the coeffcient of orifice given in the table below. This method gives static pressure and not total pressure.

COEFFICIENTS OF DISCHARGE.

Angles of Convergence	Coefficient of Discharge	Angles of Convergence	Coefficient of Discharge.
0° 0′	0.825	13° 24′	0.946
1 36	0.866	14 28	0.941
3 10	0.895	16 36	0.938
4 10	0.912	19 28	0.924
5 26	0.924	21 0	0.918
7 52	0.929	23 0	0.913
8 58	0.934	29 58	0.896
10 20	0.938	40 20	0.869
12 4	0.942	48 50	0.847

In all cases, in using the above table, pressures should be taken in the chamber from which the air is discharged.

The fan may also discharge into an air-tight chamber, the air escaping through a short length of pipe, and the static pressure be accurately measured. A coefficient of 0.825 should be applied to the area of the short pipe to determine the effective area and the velocity of the air.

(Continued on Sheet No. 9-B)

MEASUREMENT OF AIR FLOW (Continued)

In commercial work, where a test is wanted before the fan is installed, a converging nozzle may be attached directly to the fan outlet, and the velocity pressure of air measured by a Pitot tube. A proper coefficient of contraction, as shown by the table below, should be used, due to the convergence of the nozzle.

COEFFICIENTS OF CONTRACTION

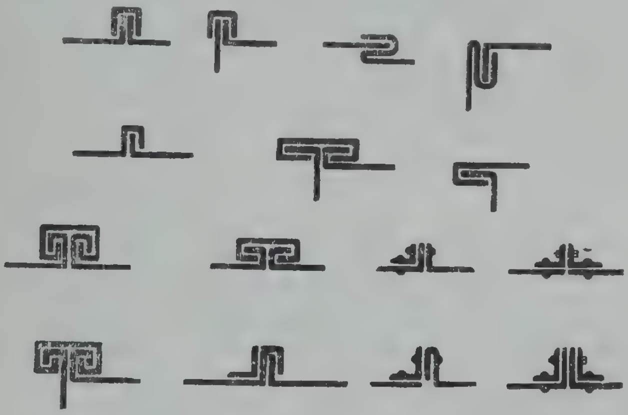
Angles of Convergence	Coefficient of Contraction	Angles of Convergence	Coeffcient of Contraction
7° 52′	0.998	23° 0′	0.937
8 58	0.992	29 58	0.919
10 20	0.987	40 20	0.887
12 4	0.986	48 50	0.861

A Pitot tube is one of the most common instruments used to determine velocity and quantity of air flowing through a pipe This has two tubes, one inside the other The outer tube has several small openings in the short bent portion which records static pressure. The inner bent tube has an opening in the end which records total pressure By properly connecting the two tubes, the difference, or velocity pressure, may be read directly In testing a fan the Pitot tube should be placed 10 to 20 diameters from the fan outlet, and the air pipe should be the same diameter as the fan outlet Velocity pressure in the center of the duct will be higher than the average, and the reading at the center of a round pipe should be multiplied by a coefficient of 0.80 to get true average velocity pressure For more accurate work in round pipes and for square or rectangular pipes, a traverse of the pipe should be taken and an average of all the readings used. When the pipe is square or rectangular, it may be divided into a number of small squares or rectangles a reading taken in the center of each, and the average result will be the true velocity pressure. If the pipe is round, it should be divided into a number of concentric rings of equal areas, and four readings taken in each area, horizontally and vertically across the pipe

DUCT AND FLUE WORK.

Ducts and flues for heating and ventilating are usually constructed of galvanized iron or masonry. When galvanized iron is used they may be round or oblong in shape and are often built of No. 24 U. S. Gauge up to 350 sq. in. of area, No. 22 U. S. Gauge from 351 to 1200 sq. in. of area and No. 20 U. S. Gauge above this, with suitable stiffeners. Castings for heaters, fan connections, fresh air intakes and other large compartments are usually built of No. 18 U. S. Gauge.

Ducts and flues are generally made in the shape of sections and joined up on the job, special connections being installed after the main lines are in place. There are various methods employed by different contractors for joining the various sections, some of the more common types being here illustrated. For smaller work the use of an angle iron is unnecessary, the standing seam giving all the stiffness required for short spans, but for spans over 4 ft.—and certainly for spans over 6 ft.—angle irons are most desirable. Some engineers specify that ducts shall be stiffened "so as to bear the weight of a man on a plank laid along the top at any location selected." Flat seams are little used in good work unless the size of the pipe is 12 in. or less.



Round pipes, from a purely efficiency standpoint, are always the best, the amount of metal required to furnish a given amount of air at a given velocity being less and the friction or resistance to the passage of the air also being reduced. In factories, shops and other industrial buildings round ducts and flues are the rule; in better classes of buildings, where space is at a premium, square or rectangular flues are used almost exclusively. The length of the long side of a rectangular flue should never be more than twice the length of the short side unless absolutely unavoidable.

Volume dampers should be placed so as to control with absolute certainty the quantity of air delivered to each outlet or inlet and it is impractical to try to design a system where such dampers are not needed.

Ducts and flues may be sized by two different methods.

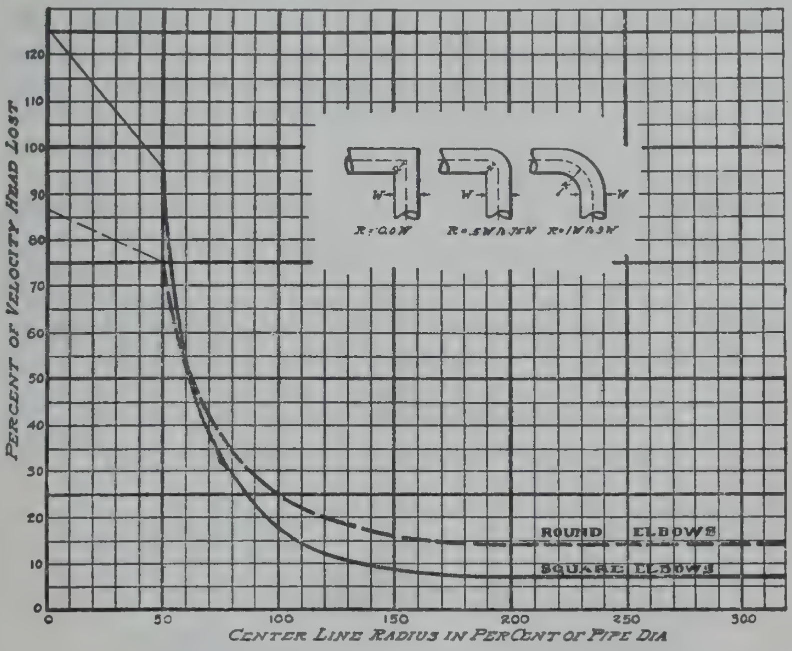
(*a*) By assuming velocities in the pipe (according to its position in the system) and calculating to find its area, or

(*b*) By assuming a proportional area of pipe to the area of the fan discharge and calculating all pipe areas on the basis of the equivalent number of 1-in. pipes.

DUCTS AND FLUES.

Elbows and Bends.

All bends and elbows should be made with a center line radius of not less than one and one-half times the width of the pipe and some prefer using two times the pipe width. Tests with elbows of various radii by Frank L. Busey and read before the A. S. H. & V. E. in 1913 indicate that the resistances vary as shown on the following curves. From these curves it can be seen that little is gained beyond one and one-half times the width and nothing at all beyond two times the width.



DUCTS AND FLUES

Anemometer Readings

The following is the method recommended by the committee appointed in 1913 by the A. S. H. & V. E. to investigate and recommend a standard method of obtaining anemometer readings of air valocities and quantities to supply and vent registers. The committee decided that all special apparatus, such as cones, plates, etc., was impractical and formulated seven rules as follows:

1. The opening shall be divided into equal rectangular areas, no side of which shall be over 10 in. long, excepting where this would require more than ten readings, in which case the opening shall be divided into twelve equal areas.
2. Readings are to be taken in every case at the center of every area.
3. Readings are to be one-half-minute duration, the anemometer being held at the register face or in the plane of the opening.
4. Where the diffusers are used, a total area is to be computed on the basis of the periphery of the diffuser.
5. The average of the readings are to be considered as the average velocity at the opening. Where negative velocities are found, they are to be deducted in arriving at the average velocity.
6. In computing volume, the net area of opening is to be taken, the volume to be considered as the product of the average velocity and the net area of the opening.
7. If the anemometer is held 2 in. from the register face, no deduction shall be made for the area occupied by the register mesh.

DUCTS AND FLUES.

Underwriters' Rules.

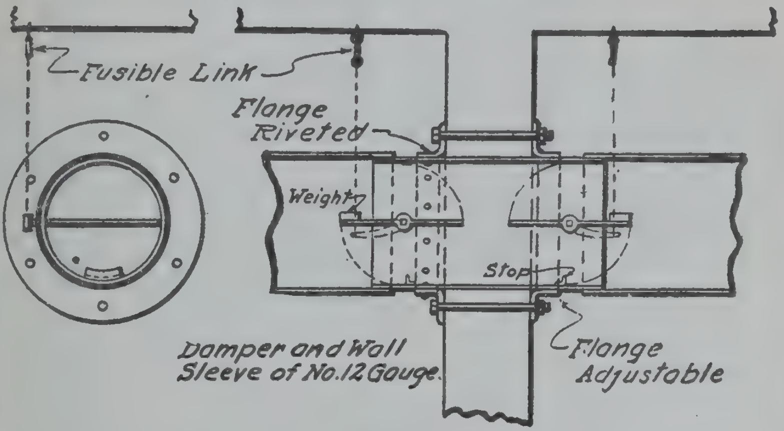


FIG. 1.

The National Board of Fire Underwriters has adopted certain rules and regulations governing heating and ventilating systems. The regulations are divided into three main divisions: (1) Fans, (2) Ducts and Flues, and (3) Kitchen and Cooking Vents. These rules are as follows:

BLOWERS. The word blowers is used to include blowers and fans.

(*a*) Blowers shall be so located as to be accessible for repairing and lubricating.

(*b*) Casings to be strongly built and properly reinforced where necessary; joints shall be air-tight. Casings and runners shall be entirely non-combustible, and large enough not to require overspeeding. To prevent accidents openings into casings shall be protected with substantial screens or their equivalent.

(*c*) Bearings and journals to be constructed in accordance with the best modern machine design and so proportioned as to prevent overheating. The bearings shall be self-oiled and so designed as to prevent leakage of oil. They shall be located outside of casings or ducts wherever possible. If located inside of casings or ducts, oilless self-lubricating bearings shall be used, made of bronze bushings fitted with plugs, such as graphite or metaline.

DUCTS. The word ducts is used to include ducts, flues, pipes and tubes.

(*a*) Openings through floors for the circulation of air from one story to another shall not be used.

(Continued on Data Sheet No. 10-D.)

DUCTS AND FLUES.

Underwriters' Rules (Continued).

(*Continued from Data Sheet No.* 10-*C*.)

(*b*) Entire system of ducts to be self-contained; no rooms, hallways, attics, hollow spaces, voids, nor other portions of the buildings shall be used for air chambers or ducts, unless of fire-resisting construction, and then only by permission of the inspection department having jurisdiction.

(*c*) Ducts shall be made of galvanized iron or other approved non-combustible material. The same applies to enclosures of steam coils used for heating air.

(*d*) To be thoroughly braced.

(*e*) To be substantially supported by metal hangers, brackets or their equivalent.

(*f*) Where subject to mechanical injury, ducts to be properly protected.

(*g*) In no case shall the clearance between any metal ducts and combustible material be less than 1 in.

(*h*) The passing of ducts through fire walls should be avoided wherever possible. Where ducts pass through fire walls they shall be provided with automatic dampers, or national standard vertical automatic fire doors, located on each side of the wall through which they pass. (See Fig. 1.)

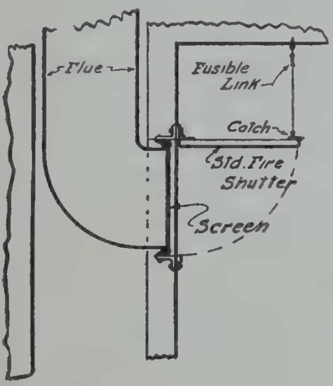


FIG. 2.

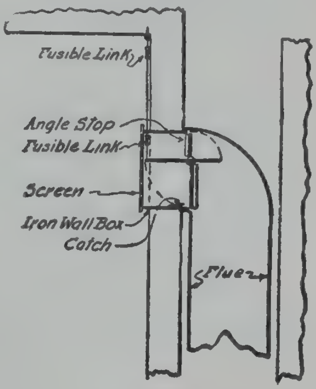


FIG. 3.

(*i*) All ducts passing through floors shall be made of, or protected throughout by approved fire-resisting material, such as 4 in. brick, hollow tile, or 2 in. cement-plastered partition, supported by a substantial steel frame.

(*Continued on Data Sheet No.* 10-*E*.)

DUCTS AND FLUES.

Underwriters' Rules (Concluded).

(Continued from Data Sheet No. 10-D.)

(*j*) Where vertical ducts serve more than one floor, automatic dampers shall be provided on all outlet openings directly from such vertical ducts, and at all connections with branch ducts from such vertical ducts. (See Figs. 2 and 3.)

(*k*) Joints between ducts and floors, walls or partitions, must be made tight by non-combustible materials.

(*l*) Outlets on supply and exhaust ducts should always be protected by means of register faces or wire screens.

(*m*) Intake of air to be from outside except in re-circulating systems, and shall be taken only from areas containing non-combustible material. Intakes must be protected with rolling shutters or heavy doors.

Intake and intake rooms, steam coils and blowers, etc. shall be segregated in a room cut off by fire-resisting partitions from other portions of the building.

(*n*) Blower systems should preferably have an emergency or automatic control to shut them down in case of fire. This may be done automatically by means of devices utilizing fusible links, thermostats, or automatic sprinklers. Such installations to be subject to the approval of the inspection department having jurisdiction.

COOKING APPLIANCES.

(*a*) Ventilating ducts used to carry off the grease-laden vapors from hoods over cooking appliances, especially in kitchens of large restaurants and hotels, shall be constructed similarly to boiler smoke flues, and, of of metal, must be of not less than No. 16 U. S. gauge, so substantially built that the grease and gum could be removed from the interior by burning out under a flash fire.

(*b*) The ventilating ducts shall be an independent system in no manner connected with other house ventilatig systems.

(*c*) Ducts should not be connected to stacks, chimneys or flues used for other purposes.

(*d*) A live steam jet should preferably be provided at the end of the duct nearest the cooking appliances.

DUCTS AND FLUES.

Velocities Recommended for Heating and Ventilating Systems, in Schools, Public Buildings, Churches, etc.

Supply Air.

	VELOCITY THROUGH FREE AREA.
Cold air intake	700 to 1000 f. p. m.
Cloth filter	about 40 “
Air washer	500 “
Heaters	800 to 1200 “
Horizontal ducts	1200 to 1400 at fan decreasing to 600 f. p. m. at base of vertical flues.
Vertical flues	400 f. p. m. for masonry flues. 500 f. p. m. for galv. iron flues.
Register outlet (free area)	200 to 250 f. p. m.
Grilles (total area)	“ “ “

Air outlets 15 ft, or more above the floor may be run up as high as 350 f. p. m. if not thrown directly down on persons below.

Exhaust Air.

	VELOCITY THROUGH FREE AREA.
Registers or total area of grilles	300 to 400 f. p. m.
Vertical flues	400 f. p. m. for masonry flues 500 f. p. m. for galv. iron flues.
Horizontal ducts	600 f. p. m. at far end up to 1200 or 1400 f. p. m. at fan inlet.
Discharge openings	700 to 1000 f. p. m.

DUCTS AND FLUES

Velocity in Vent Flues Due to Heating Air.

When air in a flue is heated above that of the outside air, into which the flue is opened, the flue air is expanded to a relatively greater volume and therefore has a relatively less weight than the outside air. This state results in a tendency to equalize the unbalanced condition, giving motive power to produce a draft in the flue largely similar to the action of a common chimney.

Ventilation operated by heating the air in vertical flues is termed a "gravity" system but cannot be recommended on account of troubles due to non-positive results, back-drafts, etc. Owing to cheapness such flues are often used and when so employed should be figured conservatively to allow for friction and other retardents. The following table is thought to be as reliable as any table can be when made to fit a set of conditions which are not positive.

VENT FLUE VELOCITIES IN FEET PER MINUTE.

Height of flue in feet	Temperature in flue above outside temperature, in degrees, Fahr.						
	5°	10°	15°	20°	30°	50°	100°
	Velocity in Flue in Feet Per Minute.						
5	55	76	94	109	134	167	242
10	77	108	133	153	188	242	342
15	94	133	162	188	230	297	419
20	108	153	188	217	265	342	484
25	121	171	210	242	297	383	541
30	133	188	230	265	325	419	593
35	143	203	248	286	351	453	640
40	153	217	265	306	375	484	684
45	162	230	282	325	398	514	724
50	171	242	297	342	419	541	765
60	188	264	325	373	461	594	835
100	238	342	420	485	594	768	1080

AREA IN SQUARE FEET OF ANY ROUND, SQUARE OR RECTANGULAR PIPE FROM 8 INCHES TO 8 FEET

Side or Diameter Inches	Round Pipe	Square or Oblong Pipe																											
8	0.35	0.45																											
9	0.44	0.50	0.56																										
10	0.55	0.56	0.62	0.69																									
11	0.66	0.61	0.69	0.76	0.84																								
12	0.79	0.67	0.75	0.83	0.92	1.00																							
13	0.92	0.72	0.81	0.90	0.99	1.08	1.17																						
14	1.07	0.78	0.87	0.97	1.06	1.17	1.26	1.36																					
15	1.23	0.83	0.94	1.04	1.14	1.25	1.35	1.46	1.56																				
16	1.39	0.89	1.00	1.11	1.22	1.33	1.44	1.55	1.67	1.78																			
17	1.57	0.94	1.06	1.18	1.29	1.42	1.53	1.65	1.77	1.89	2.01																		
18	1.76	1.00	1.12	1.25	1.37	1.50	1.62	1.75	1.87	2.00	2.12	2.25																	
19	1.97	1.06	1.19	1.32	1.45	1.58	1.71	1.84	1.98	2.11	2.24	2.37	2.50																
20	2.18	1.11	1.25	1.38	1.52	1.67	1.80	1.94	2.08	2.22	2.36	2.50	2.63	2.78															
22	2.64	1.22	1.38	1.52	1.68	1.83	1.98	2.13	2.29	2.44	2.60	2.75	2.90	3.05	3.36														
24	3.14	1.33	1.50	1.67	1.83	2.00	2.17	2.33	2.50	2.67	2.83	3.00	3.17	3.33	3.67	4.00													
26	3.69	1.44	1.62	1.80	1.98	2.17	2.34	2.53	2.71	2.89	3.07	3.25	3.43	3.62	3.97	4.33	4.70												
28	4.27	1.56	1.75	1.94	2.14	2.33	2.52	2.72	2.92	3.11	3.30	3.50	3.69	3.89	4.28	4.67	5.06	5.45											
30	4.90	1.67	1.88	2.08	2.29	2.50	2.71	2.92	3.12	3.33	3.54	3.75	3.96	4.17	4.58	5.00	5.41	5.83	6.25										
32	5.58	1.78	2.00	2.22	2.44	2.67	2.89	3.11	3.33	3.56	3.78	4.00	4.22	4.44	4.89	5.33	5.78	6.22	6.67	7.11									
34	6.30	1.89	2.12	2.36	2.59	2.83	3.07	3.30	3.54	3.78	4.02	4.25	4.48	4.72	5.19	5.67	6.15	6.61	7.09	7.56	8.03								
36	7.06	2.00	2.25	2.50	2.75	3.00	3.25	3.50	3.75	4.00	4.25	4.50	4.75	5.00	5.50	6.00	6.50	7.00	7.50	8.00	8.50	9.00							
38	7.87	2.11	2.38	2.63	2.90	3.17	3.43	3.69	3.96	4.22	4.50	4.75	5.01	5.28	5.80	6.33	6.86	7.39	7.91	8.44	8.97	9.50	10.03						
40	8.73	2.22	2.50	2.77	3.05	3.33	3.61	3.89	4.17	4.44	4.73	5.00	5.28	5.56	6.11	6.67	7.23	7.78	8.33	8.89	9.44	10.00	10.56	11.11					
42	9.62	2.33	2.62	2.91	3.21	3.50	3.79	4.08	4.38	4.67	4.96	5.25	5.54	5.83	6.42	7.00	7.58	8.17	8.75	9.33	9.91	10.50	11.09	11.67	12.25				
44	10.56	2.44	2.75	3.05	3.36	3.67	3.97	4.28	4.58	4.89	5.19	5.50	5.81	6.11	6.71	7.33	7.94	8.56	9.16	9.78	10.38	11.00	11.61	12.22	12.83	13.44			
46	11.54	2.56	2.88	3.19	3.51	3.83	4.15	4.47	4.79	5.11	5.44	5.75	6.07	6.38	7.01	7.67	8.31	8.95	9.58	10.22	10.85	11.50	12.14	12.78	13.42	14.06	14.69		
48	12.56	2.67	3.00	3.33	3.67	4.00	4.33	4.67	5.00	5.33	5.67	6.00	6.33	6.67	7.33	8.00	8.67	9.33	10.00	10.67	11.33	12.00	12.67	13.33	14.00	14.67	15.33	16.00	
50	13.63	2.78	3.12	3.47	3.82	4.17	4.51	4.86	5.21	5.56	5.92	6.25	6.60	6.95	7.63	8.33	9.03	9.72	10.42	11.11	11.80	12.50	13.20	13.89	14.58	15.28	15.97	16.67	17.36
Side of pipe inches		8	9	10	11	12	13	14	15	16	17	18	19	20	22	24	26	28	30	32	34	36	38	40	42	44	46	48	50

AREA IN SQUARE FEET OF ANY ROUND, SQUARE OR RECTANGULAR PIPE FROM 8 INCHES TO 8 FEET

SIZE OF PIPE - - INCHES

SIZE OF PIPES - - - INCHES	96	94	92	90	88	86	84	82	80	78	76	74	72	70	68	66	64	62	60	58	56	54	52
96	64.00	62.67	61.33	60.00	58.67	57.33	56.00	54.67	53.33	52.00	50.67	49.33	48.00	46.67	45.33	44.00	42.67	41.33	40.00	38.67	37.33	36.00	34.67
94		61.36	60.05	58.75	57.43	56.14	54.83	53.53	52.22	50.92	49.61	48.30	47.00	45.70	44.39	43.08	41.78	40.47	39.17	37.86	36.56	35.25	33.95
92			58.78	57.50	56.23	54.95	53.67	52.39	51.11	49.83	48.56	47.28	46.00	44.72	43.44	42.16	40.89	39.61	38.33	37.05	35.78	34.50	33.23
90				56.25	55.00	53.75	52.50	51.25	50.00	48.75	47.50	46.25	45.00	43.75	42.5[illegible]	41.25	40.00	38.75	37.50	36.25	35.00	33.75	32.50
88					53.77	52.55	51.33	50.11	48.89	47.67	46.44	45.22	44.00	42.78	41.55	40.33	39.11	37.89	36.67	35.44	34.22	33.00	31.78
86						51.36	50.17	48.97	47.78	46.58	45.39	44.19	43.00	41.81	40.61	39.42	38.22	37.03	35.83	34.63	33.44	32.25	31.05
84							49.00	47.83	46.67	45.50	44.33	43.16	42.00	40.84	39.67	38.50	37.33	36.17	35.00	33.83	32.67	31.50	30.33
82								46.69	45.55	44.[illegible]	43.28	42.14	41.00	39.86	38.72	37.58	36.44	35.31	34.17	33.03	31.89	30.75	29.61
80									44.44	43.33	42.22	41.11	40.00	38.89	37.78	36.67	35.56	34.44	33.33	32.22	31.11	30.00	28.89
78										42.25	41.17	40.08	39.00	37.92	36.83	35.75	34.67	33.58	32.50	31.42	30.33	29.25	28.17
76											40.11	39.05	38.00	36.94	35.89	34.83	33.78	32.72	31.67	30.61	29.56	28.50	27.44
74												38.03	37.00	35.97	34.94	33.92	32.89	31.86	30.83	29.80	28.78	27.75	26.72
72													36.00	35.00	34.00	33.00	32.00	31.00	30.00	29.00	28.00	27.00	26.00
70														34.03	33.06	32.08	31.11	30.14	29.17	28.19	27.22	26.25	25.28
68															32.11	31.16	30.22	29.28	28.33	27.39	26.44	25.50	24.56
66																30.25	29.33	28.42	27.50	26.58	25.67	24.75	23.83
64																	28.44	27.56	26.67	25.78	24.89	24.00	23.11
62																		26.69	25.83	24.97	24.11	23.25	22.39
60																			25.00	24.17	23.33	22.50	21.67
58																				23.36	22.56	21.75	20.94
56																					21.78	21.00	20.23
54																						20.25	19.50
52																							18.78

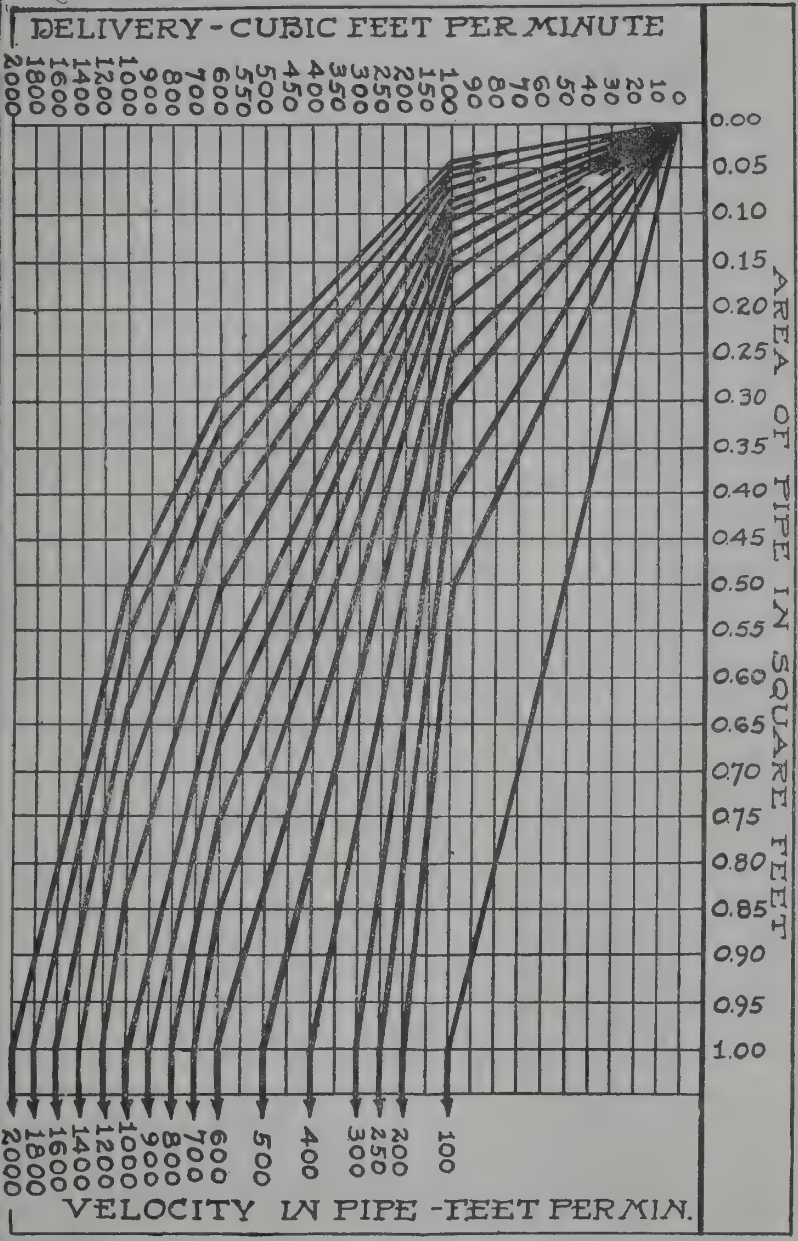
(For continuation of this table see Data Sheet No. 10-I.)

AREA IN SQUARE FEET OF ANY ROUND, SQUARE OR RECTANGULAR PIPE FROM 8 INCHES TO 8 FEET.

Side or Diameter Inches	Round Pipe	AREA OF SQUARE OR RECTANGULAR PIPES IN SQUARE FEET																											
52	14.75	2.89	3.25	3.61	3.97	4.33	4.69	5.06	5.41	5.78	6.14	6.50	6.86	7.23	7.93	8.07	9.39	10.11	10.83	11.56	12.28	13.00	13.73	14.44	15.17	15.88	16.61	17.33	18.06
54	15.90	3.00	3.38	3.75	4.13	4.50	4.88	5.25	5.62	6.00	6.38	6.75	7.13	7.50	8.25	9.00	9.75	10.50	11.25	12.00	12.75	13.50	14.25	15.00	15.75	16.50	17.25	18.00	18.75
56	17.10	3.11	3.50	3.89	4.28	4.67	5.05	5.44	5.83	6.22	6.61	7.00	7.39	7.77	8.56	9.33	10.11	10.89	11.67	12.44	13.22	14.00	14.78	15.55	16.33	17.12	17.88	18.67	19.44
58	18.34	3.22	3.63	4.02	4.43	4.83	5.23	5.64	6.04	6.44	6.85	7.25	7.65	8.06	8.86	9.67	10.47	11.28	12.08	12.89	13.69	14.50	15.31	16.11	16.92	17.72	18.53	19.33	20.14
60	19.63	3.33	3.75	4.16	4.59	5.00	5.41	5.83	6.25	6.67	7.10	7.50	7.92	8.33	9.17	10.00	10.83	11.67	12.50	13.33	14.17	15.00	15.85	16.67	17.50	18.33	19.16	20.07	20.84
62	20.96	3.44	3.88	4.30	4.74	5.17	5.59	6.02	6.46	6.89	7.32	7.75	8.18	8.61	9.47	10.33	11.21	12.06	12.92	13.78	14.64	15.50	16.37	17.22	18.08	18.95	19.80	20.67	21.53
64	22.34	3.56	4.00	4.44	4.88	5.33	5.77	6.22	6.67	7.11	7.56	8.00	8.42	8.89	9.77	10.67	11.56	12.44	13.33	14.22	15.11	16.00	16.90	17.77	18.67	19.56	20.44	21.33	22.22
66	23.76	3.67	4.12	4.58	5.05	5.50	5.95	6.41	6.87	7.33	7.80	8.25	8.71	9.17	10.08	11.00	11.91	12.83	13.75	14.67	15.58	16.50	17.43	18.33	19.25	20.17	21.08	22.00	22.92
68	25.21	3.78	4.25	4.72	5.19	5.67	6.13	6.61	7.08	7.56	8.04	8.50	8.98	9.46	10.39	11.33	12.28	13.22	14.17	15.11	16.05	17.00	17.95	18.83	19.83	20.78	21.72	22.67	23.61
70	26.72	3.89	4.38	4.86	5.34	5.83	6.31	6.80	7.29	7.78	8.26	8.75	9.24	9.73	10.67	11.67	12.64	13.61	14.58	15.56	16.53	17.50	18.48	19.44	20.42	21.38	22.36	23.33	24.30
72	28.27	4.00	4.50	5.00	5.50	6.00	6.50	7.00	7.50	8.00	8.50	9.00	9.50	10.00	11.00	12.00	13.00	14.00	15.00	16.00	17.00	18.00	19.00	20.00	21.00	22.00	23.00	24.00	25.00
74	29.86	4.11	4.62	5.14	5.65	6.17	6.68	7.19	7.71	8.22	8.76	9.25	9.76	10.28	11.30	12.33	13.36	14.39	15.42	16.44	17.47	18.50	19.53	20.56	21.58	22.61	23.63	24.67	25.69
76	31.50	4.22	4.75	5.27	5.80	6.33	6.86	7.39	7.91	8.44	8.97	9.50	10.03	10.56	11.60	12.67	13.72	14.78	15.83	16.89	17.94	19.00	20.06	21.11	22.17	23.22	24.27	25.33	26.39
78	33.18	4.33	4.83	5.41	5.95	6.50	7.04	7.58	8.12	8.67	9.21	9.75	10.29	10.83	11.91	13.00	14.08	15.17	16.25	17.33	18.41	19.50	20.59	21.67	22.75	23.83	24.91	26.00	27.08
80	34.90	4.44	5.00	5.56	6.11	6.67	7.22	7.78	8.33	8.89	9.44	10.00	10.56	11.11	12.22	13.33	14.44	15.56	16.67	17.78	18.89	20.00	21.11	22.22	23.33	24.44	25.56	26.67	27.78
82	36.67	4.56	5.12	5.69	6.26	6.83	7.40	7.97	8.54	9.11	9.68	10.25	10.82	11.39	12.53	13.67	14.80	15.94	17.08	18.22	19.36	20.50	21.64	22.77	23.92	25.06	26.19	27.33	28.47
84	38.48	4.67	5.25	5.83	6.42	7.00	7.58	8.17	8.75	9.33	9.92	10.50	11.08	11.67	12.83	14.00	15.17	16.33	17.50	18.67	19.83	21.00	22.17	23.33	24.50	25.67	26.83	28.00	29.17
86	40.33	4.78	5.38	5.97	6.57	7.17	7.76	8.36	8.96	9.56	10.15	10.75	11.34	11.94	13.14	14.33	15.53	16.72	17.92	19.11	20.30	21.50	22.70	23.89	25.09	26.29	27.46	28.67	29.86
88	42.24	4.89	5.50	6.11	6.72	7.33	7.94	8.56	9.16	9.78	10.39	11.00	11.61	12.22	13.44	14.67	15.90	17.11	18.33	19.56	20.78	22.00	23.22	24.44	25.67	26.90	28.10	29.33	30.56
90	44.18	5.00	5.62	6.25	6.88	7.50	8.12	8.75	9.37	10.00	10.62	11.25	11.88	12.50	13.75	15.00	16.25	17.50	18.75	20.00	21.25	22.50	23.75	25.00	36.25	27.50	28.75	30.00	31.25
92	46.16	5.11	5.75	6.38	7.02	7.67	8.30	8.94	9.58	10.22	10.86	11.50	12.14	12.78	14.06	15.33	16.61	17.89	19.17	20.44	21.72	23.00	24.28	25.56	26.83	28.11	29.37	30.67	31.94
94	48.19	5.22	5.88	6.52	7.18	7.83	8.48	9.14	9.79	10.44	11.10	11.75	12.40	13.06	14.36	15.67	16.97	18.28	19.58	20.89	22.19	23.50	24.81	26.11	27.42	28.72	30.00	31.33	32.64
96	50.26	5.33	6.00	6.67	7.33	8.00	8.67	9.33	10.00	10.67	11.33	12.00	12.67	13.33	14.67	16.00	17.33	18.67	20.00	21.33	22.67	24.00	25.33	26.67	28.00	29.33	30.67	32.00	33.33
Side of Pipe Inches		8	9	10	11	12	13	14	15	16	17	18	19	20	22	24	26	28	30	32	34	36	38	40	42	44	46	48	50

(For first portion of this table see Data Sheet No. 10-H.)

CUBIC FEET DELIVERED FOR ANY SIZE PIPE AT ANY VELOCITY



NOTE—For areas of pipe larger than those given in curves move the decimal point of the given area one or two places to left so as to reduce the area to within the limits between zero and 1.00; read the result from the curve and add the same number of ciphers to the result as the number of places the decimal point was moved.

PROPER GAUGES AND WEIGHTS OF ROUND G. I. PIPE AND ELBOWS FOR DUCT SYSTEMS

Gauge and Weight per Square Foot	Diam. of Pipe In.	Weight per Lineal Ft., Lbs.	Weight of Full Ell Lbs.	Gauge and Weight per Square Foot	Diam. of Pipe In.	Weight per Lineal Ft., Lbs.	Weight of Full Ell, Lbs.
28 g. 0.78 lbs.	3	0.7	0.4	20 g 1.66 lbs.	38	18.2	139.4
" "	4	1.1	0.9	" "	39	18.7	146.0
" "	5	1.2	1.2	" "	40	19.1	152.9
" "	6	1.4	1.7	" "	41	19.6	160.7
" "	7	1.7	2.3	" "	42	20.1	168.6
" "	8	1.9	2.9	" "	43	20.6	176.7
26 g. 0.91 lbs.	9	2.4	4.3	" "	44	21.0	185.0
" "	10	2.7	5.3	" "	45	21.5	193.4
" "	11	2.9	6.4	" "	46	22.0	202.2
" "	12	3.2	7.6	18 g. 2.16 lbs.	47	29.2	274.3
" "	13	3.4	8.9	" "	48	29.8	286.6
" "	14	3.7	10.4	" "	49	30.4	298.8
25 g. 1.03 lbs.	15	4.5	13.5	" "	50	31.0	309.9
" "	16	4.7	15.1	" "	51	31.6	322.5
" "	17	5.0	17.0	" "	52	32.2	335.1
" "	18	5.3	19.1	" "	53	33.0	349.7
" "	19	5.6	21.4	" "	54	33.6	363.4
" "	20	6.0	23.9	" "	55	34.4	377.2
24 g. 1.16 lbs.	21	7.0	29.6	" "	56	34.9	390.7
" "	22	7.3	32.3	" "	57	35.6	405.1
" "	23	7.7	35.6	" "	58	36.1	418.8
" "	24	8.0	38.6	" "	59	36.7	433.1
" "	25	8.3	41.7	" "	60	37.4	448.6
" "	26	8.7	45.1	16 g. 2.66 lbs.	61	46.7	569.7
22 g. 1.41 lbs.	27	10.9	59.1	" "	62	47.5	589.0
" "	28	11.4	64.2	" "	63	48.3	608.6
" "	29	11.8	68.6	" "	64	49.1	628.5
" "	30	12.2	73.4	" "	65	49.8	647.4
" "	31	12.6	78.3	" "	66	50.5	666.6
" "	32	13.0	83.4	" "	67	51.3	687.4
" "	33	13.5	88.9	" "	68	52.1	708.6
" "	34	13.9	94.3	" "	69	52.8	728.6
" "	35	14.3	99.9	" "	70	53.6	750.4
20 g. 1.66 lbs.	36	17.2	124.4	" "	71	54.3	771.0
" "	37	17.8	131.4	" "	72	55.1	793.4

In this table the weights include rivets, solder and due allowance for trimming and laps; the elbows have an internal radius equal to the diameter of the pipe. Rectangular pipes are usually made of same gauge as round pipes of equal area.

B. F. Sturtevant Co.

FACTORS FOR REDUCING WEIGHT OF G. I. PIPE OF ANY GIVEN GAUGE TO THAT OF ANY OTHER GAUGE.

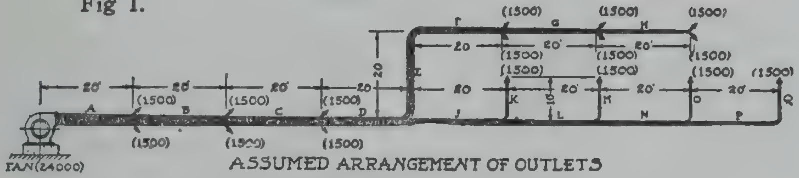
Given Gauge	OTHER GAUGES AND WEIGHT IN POUNDS PER SQUARE FOOT																
	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
	4.53	3.91	3.28	2.97	2.66	2.41	2.16	1.90	1.66	1.53	1.41	1.28	1.16	1.03	.91	.84	.78
12	1.00	.86	.72	.66	.59	.53	.48	.47	.37	.34	.31	.28	.26	.23	.20	.19	.17
13	1.16	1.00	.84	.76	.68	.62	.55	.49	.43	.39	.36	.33	.30	.26	.23	.22	.20
14	1.38	1.19	1.00	.91	.81	.74	.66	.58	.51	.47	.43	.39	.35	.32	.28	.26	.24
15	1.53	1.32	1.10	1.00	.90	.81	.73	.64	.56	.52	.48	.43	.39	.35	.31	.28	.27
16	1.70	1.47	1.23	1.11	1.00	.91	.81	.71	.62	.58	.53	.48	.44	.39	.34	.32	.29
17	1.88	1.62	1.36	1.23	1.10	1.00	.90	.79	.69	.63	.59	.53	.48	.43	.38	.35	.32
18	2.10	1.81	1.52	1.38	1.23	1.12	1.00	.88	.77	.71	.65	.59	.54	.48	42	.39	.36
19	2.38	2.06	1.73	1.56	1.40	1.27	1.14	1.00	.87	.81	.74	.67	.61	.54	.48	.44	.41
20	2.72	2.36	1.98	1.79	1.60	1.45	1.30	1.16	1.00	.92	.85	.77	.70	.62	.55	.51	.47
21	2.96	2.56	2.14	1.94	1.74	1.57	1.41	1.24	1.09	1.00	.92	.84	.76	.67	.59	.55	.51
22	3.21	2.77	2.32	2.10	1.89	1.71	1.53	1.35	1.18	1.08	1.00	.91	.82	.73	.65	.60	.55
23	3.54	3.07	2.56	2.32	2.08	1.88	1.69	1.49	1.30	1.20	1.10	1.00	.91	.81	.71	.66	.61
24	3.90	3.37	2.82	2.56	2.29	2.08	1.86	1.61	1.43	1.32	1.22	1.10	1.00	.89	.78	.72	.67
25	4.40	3.79	3.18	2.88	2.58	2.34	2.10	1.86	1.61	1.49	1.37	1.24	1.12	1.00	.88	.82	.76
26	4.98	4.30	3.60	3.26	2.92	2.65	2.37	2.10	1.82	1.68	1.55	1.41	1.27	1.13	1.00	.92	.86
27	5.40	4.66	3.90	3.54	3.17	2.87	2.57	2.28	1.96	1.82	1.68	1.52	1.38	1.23	1.08	1.00	.93
28	5.81	5.01	4.20	3.80	3.41	3.09	2.77	2.45	2.13	1.96	1.81	1.64	1.49	1.32	1.17	1.08	1.00

Example: To find weight of 28-in. pipe of No. 16 gauge. On data sheet No. 10-K, 28-in. pipe of No. 22 gauge weighs 11.4 lbs. Picking out the No. 22 gauge line in the above table and following across to the column marked "16 g." we find the correction factor 1.89 and 11.4x1.89=21.55 lbs., if made of No. 16 gauge metal.

B. F. Sturtevant Co.

SIZING OF DUCTS AND FLUES
METHOD NO. 1.

Fig 1.



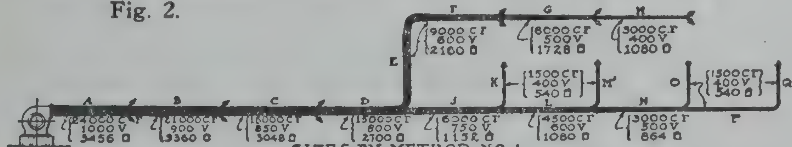
ASSUMED ARRANGEMENT OF OUTLETS

Fig. 1 involves supplying 1,500 cu. ft. of air to each of sixteen outlets, located as shown, from a fan placed at the left-hand end. It is assumed that these outlets are in different rooms but that air requirements are the same or, if the air is used for heating, that the heat requirements are identical.

Assume velocities in the ducts ranging from 1,000 ft. per minute at the fan down to 500 ft. per minute in mains P and H. Size the ducts on the basis of the area required to pass the given quantity of air at the given velocity. Size flues on the basis of 400 ft. per minute velocity; size the registers on the basis of 250 ft. per minute velocity through the free area.

This gives a schedule of sizes as shown in the following table:

Fig. 2.



SIZES BY METHOD NO 1.

SOLUTION OF PROBLEM SHOWN IN FIG. 1, ACCORDING TO METHOD USED BY WRITER.

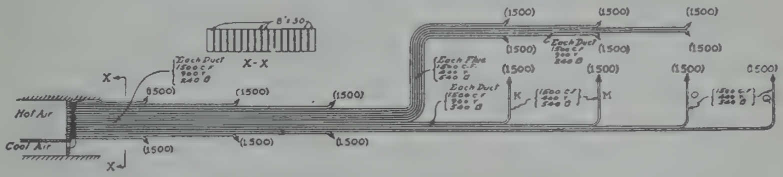
Duct or Flue	Length	Cubic Feet per Min.	Velocity Ft. Per. Min.	Area Sq. In.
A	Immaterial	24,000	1,000	3456
B	"	21,000	900	3360
C	"	18,000	850	3048
D	"	15,000	800	2700
E	"	9,000	600	2160
F	"	9,000	600	2160
G	"	6,000	500	1728
H	"	3,000	400	1080
J	"	6,000	750	1152
K	"	1,500	400	540
L	"	4,500	600	1080
M	"	1,500	400	540
N	"	3,000	500	864
O	"	1,500	400	540
P	"	1,500	400	540
Q	"	1,500	400	540

Registers equal 1500/250, or 6 sq. ft. net. This method is short, simple and in practice gives good results, the areas being as shown in Fig. 2.

SIZING DUCTS AND FLUES.

Method No. 2.

NOTE—In THE HEATING AND VENTILATING MAGAZINE for October, 1916, in an article by Harold L. Alt, various methods of sizing ducts and flues were outlined and examples shown. These comprise in all six different schemes of which one of each is illustrated and briefly outlined in Standard Data Sheets Nos. 10-M, 10-N, 10-O, 10-P, 10-Q, 10-R and 10-S. The example assumed for comparison is shown in Data Sheet No. 10-M (Fig. 1) and the reader is referred to the article in question for a more complete discussion of the subject.



Another method is not to use a trunk line at all unless all the outlets are in the same room. Where different rooms are supplied with air, different temperature requirements are encountered and this is taken care of by an individual duct system. In this system a single, separate duct is carried to each room (in this case, each outlet) and the air is supplied at the warmer or cooler temperature required. Automatic control operates mixing dampers in the hot and cold air chambers so as to give the desired temperature.

This method is illustrated diagrammatically herewith, the velocity in the flues being 400 ft. per minute and in the ducts being 850 to 900 ft. per minute; the ducts are made 8 in. wide by the depth required to give this velocity.

1500/850 = 1.76 sq. ft. × 144 = 253.44 sq. in. and this divided by 8 = 31 + in. depth, 30 in. is usually adopted.

Velocity through registers, 300 ft. per minute through free area. This gives a schedule of ducts and flues as shown in the following table:

DUCT AND FLUE SIZES AS FIGURED BY METHOD NO. 2.

Ducts and Flues.	Length.	Cu. Ft. Per Min.	Velocity Ft. Per. Min.	Area Sq. In.
All Ducts	Immaterial	1500	900	240
All Flues	Immaterial	1500	400	540

Registers 1500/300 = 5 sq. ft. net.

SIZING DUCTS AND FLUES.

Method No. 3.

The United States Government employs a method based on using the same velocity throughout the ducts, with modifications, reducing velocity beyond the center of distribution and increasing it before the center is reached. This method consists of reducing the size of the fan outlet to an equivalent number of 1-in. pipes and dividing this equivalent number of 1-in. pipes by the amount of air handled per minute; this gives a decimal by means of which the area of any duct is obtained by multiplying the cubic feet of air per minute carried by this decimal.

TABLE 1—CALCULATIONS ACCORDING TO U. S. GOVERNMENT METHOD.

Cubic Feet perMin.	Distance Ft.	Add for Turns Ft.	Equivalent Distance Ft.	Cubic Feet Times Lineal Feet
Two of 1500 ea.	20	—	20	60,000
Two of 1500 ea.	40	—	40	120,000
Two of 1500 ea.	60	—	60	180,000
1500	100	—	100	150,000
1500	120	—	120	180,000
1500	140	—	140	210,000
1500	160	—	160	240,000
Two of 1500	100	50 (a)	150	450,000
Two of 1500	120	50 (a)	170	510,000
Two of 1500	140	50 (a)	190	570,000
				2,670,000

(a) Assumed at 30 in. diameter and 10 diameters for throat radius equal to 1 D.

Then multiplying the cubic feet at each outlet by the distance back to the fan, adding the totals and dividing their sum by the total cubic feet of air per minute will give the number of feet to the center of distribution from the fan. One-third of 1% is added for each foot beyond this center and 1/3 of 1% subtracted for each foot less than this center. The velocity in the vertical flues is 600, and 200 ft. per minute through gross area of register face.

Thus, referring to Fig. 1 the outlets starting from the fan are as shown in Table 1.

2,670,000 ÷ 24,000 = 111 ft.

This is so near 110 ft. that 110 ft. may be taken for the sake of even figures. Then corrections on areas will be as shown in Table 2.

TABLE 2—CORRECTIONS ON AREAS.

Duct Supplying Outlet or Flue.	Center of Distribution, Ft.	Outlet Distance, Feet	Feet	Correction Factor	Per-Centage
A	110	20	—90	0.0033	—0.30
B	110	40	—70	0.0033	—0.23
C	110	60	—50	0.0033	—0.17
D	110	80	—30	0.0033	—0.10
EF	110	150 (a)	+40	0.0033	+0.13
G	100	170 (a)	+60	0.0033	+0.20
H	110	190 (a)	+80	0.0033	+0.27
J	110	100	—10	0.0033	—0.03
L	110	120	+10	0.0033	+0.03
N	110	140	+30	0.0033	+0.10
P	110	160	+50	0.0033	+0.16

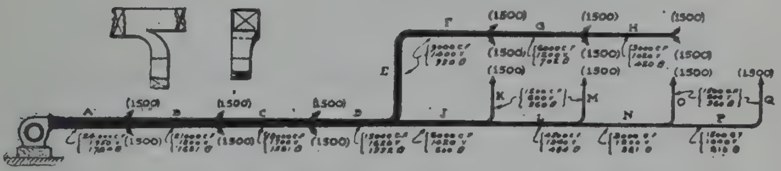
(a) 50 ft. added as equivalent for two 90° bends.

(*Continued on Sheet No. 10-P.*)

SIZING OF DUCTS AND FLUES.

Method No. 3 (Con'd).

(Continued from Data Sheet No. 10-O.)



SIZES BY METHOD NO. 3.

To get size of fan discharge and, therefore, the size of duct at the fan the size of fan must be first computed by the formula:

Cubic feet of air per minute $= AD^2N$.
$A = 0.42$ for air washer and ventilation fan.
C. F. M. $= 24{,}000$.
Tip speed of steel plate fan with air washer $= 4{,}500$.

Outlet or End Duct	Air for Outlet C.F.M.	Equiv. 1" Pipes at Factor .476	Correction %	Correction 1" Pipes	Total 1" Pipes for Outlet	Total 1" Pipes for Duct	Size of Duct	Area Sq. in.
A	3000	1428	-.30	-426	1002	11460	42x42	1764
B	3000	1428	-.23	-328	1100	10458	41x41	1681
C	3000	1428	-.17	-243	1185	9358	39x39	1521
D	No Out	–	–	–	–	8173	36x37	1332
E	"	–	–	–	–	5140	30x31	930
F	3000	1428	+.13	+186	1614	5140	30x31	930
G	3000	1428	+.20	+285	1713	3526	26x27	702
H	3000	1428	+.27	+385	1813	1813	20x21	420
J	No Out	–	–	–	–	3033	24x25	600
*K	1500	714	-.03	-21	693	–	–	360
L	No Out	–	–	–	–	2340	22x22	484
*M	1500	714	+.03	+21	735	–	–	360
N	No Out	–	–	–	–	1605	19x19	361
*O	1500	714	+.10	+71	785	–	–	360
P	No Out	–	–	–	–	820	14x15	210
*Q	1500	714	+.15	+106	820	–	–	360

*Note.. At 600 velocity or $\frac{1500}{600}$ = 2½ □' or .... : 360□"

BASIS OF COMPUTING SIZES OF DUCTS AND FLUES, METHOD NO. 3.

Therefore, $\frac{4500}{\pi D} = N$, or

$$\frac{1430}{D} = N.$$

$$\text{C.F.M.} = 0.42\ D^2 \frac{1430}{D} = 0.42$$

$D^2 \times 1430 = 600.60\ D^2$ and

$$D^2 = \frac{\text{C.F.M.}}{600} \text{ or } \frac{24000}{600}$$

$D^2 = 40$ and $D = \sqrt{40} = 6.3$ say 6-ft. wheel, or a 120-in. fan.

A 6-ft. wheel at 4,500 ft. per minute tip velocity equals:

$$6 \times 3.14 \times N = 4500$$
$$18.84\ N = 4500$$
$$N = 4500 \div 18.85 = 238$$

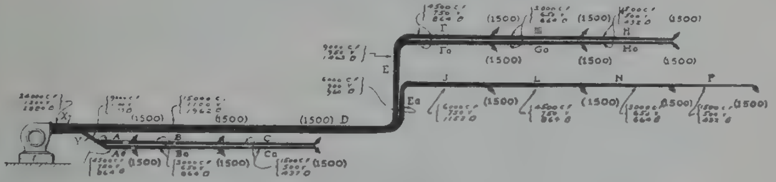
A 72-in. steel plate fan wheel has housing 57% of diameter of wheel, or $72 \times 0.57 = 41.04$ in. say 42-in. housing and 42 in. x 42 in. outlet. Then the duct size at the fan will be 42 in. x 42 in., or equivalent to 11432 1-in. square pipes.

$11432 \div 24000 = 0.476$ factor.

In making branches the practice in this system is to make the branch the full height of the main, regardless of how narrow this makes the branch, put on the elbow, then transform into a circular or square duct as desired. This is illustrated by the detail of branch shown. The basis of computing the sizes of ducts and flues as shown is given herewith and can be readily followed.

SIZING OF DUCTS AND FLUES—METHOD NO. 4

(New York City Board of Education)



SIZES BY METHOD NO. 4.

Note.—For explanation and example assumed see Standard Data Sheets Nos. 10-M. and 10-N.

In the New York City schools still another method is used. Here the outlets for any one section of a given floor are taken from a duct run horizontally on the ceiling of that floor, the duct being supplied from a main vertical flue, the bottom of which is kept as close to the supply fan as the exigencies will permit. Between the fan and the flues a velocity of 1,000 to 1,200 ft. per minute is maintained and, in the flues, a velocity depending on the height of the flue. The ducts running along the ceilings of the upper floors are arbitrarily graduated from 375 at the farther end up to 750 near the supply flue. In order to supply the sixteen outlets under consideration the duct and flue system would be rearranged as shown so that each floor would be supplied from a horizontal duct located on the ceiling of that particular floor.

The vertical flues are assumed at velocities as follows: 5-story, 1100 F. P. M.; 4-story, 1050 F. P. M.; 3-story, 1000 F. P. M.; 2-story, 950 F. P. M.; 1-story, 900 F. P. M.

SIZING CEILING DUCTS.

Number of Rooms at 1500 cu. ft. each.	Total Cubic Feet per min.	Horizontal Velocity Feet per min.	Area of Duct. Sq. In.
7½	11,250	750	2160
7	10,500	750	2016
6½	9,750	750	1872
6	9,000	750	1728
5½	8,250	750	1584
5	7,500	750	1440
4½	6,750	750	1296
4	6,000	750	1152
3½	5,250	750	1008
3	4,500	750	864
2½	3,750	700	771
2	3,000	650	664
1½	2,250	600	540
1	1,500	500	432
½	750	375	288

Registers at 250 ft. velocity over gross area.

This gives duct and flue sizes about as follows:

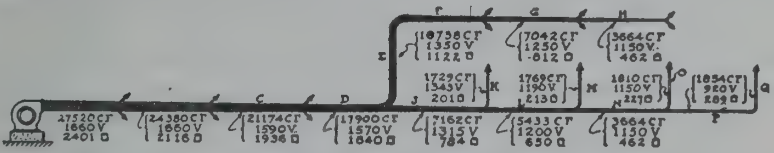
DUCT AND FLUE SIZES

Duct or Flue	Length	Cubic Ft. per Min.	Velocity Feet per Min.	Area. Sq. In.
X	Immaterial	24,000	1200	2880
Y	Immaterial	9,000	1100	1177
A	Immaterial	4,500	750	864
Aa	Immaterial	4,500	750	864
B	Immaterial	3,000	650	664
Ba	Immaterial	3,000	650	664
C	Immaterial	1,500	500	432
Ca	Immaterial	1,500	500	432
D	Immaterial	15,000	1100	1962
E	Immaterial	9,000	950	1463
Ea	Immaterial	6,000	900	960
F	Immaterial	4,500	750	864
Fa	Immaterial	4,500	750	864
G	Immaterial	3,000	650	664
Ga	Immaterial	3,000	650	664
H	Immaterial	1,500	500	432
Ha	Immaterial	1,500	500	432
J	Immaterial	6,000	750	1152
L	Immaterial	4,500	750	864
N	Immaterial	3,000	650	664
P	Immaterial	1,500	500	432

The registers are figured at 250 ft. per minute velocity over the gross area and, as wire grilles are used, this is practically 250 ft. per minute across the net area, too. The reason for two ceiling ducts apparently paralleling each other is to prevent the open windows on one side of the building from blowing the air across the duct into the other side. In reality these two ducts consist of a single duct with a middle partition.

SIZING OF DUCTS AND FLUES METHOD NO. 5.

Note.—For explanation and example assumed see Standard Data Sheets Nos. 10-M and 10-N.



SIZES BY METHOD NO 5

A method used by another prominent engineer provides for temperature drop in the duct and then utilizes the equivalent number of 1-in. pipes in determining the duct areas. The amount of temperature drop is variable, depending upon the material used for the construction of the duct, its location, and its insulation. It is a very simple proposition to test the temperature drop for any length of run in an installation already working and to thus develop the number of feet of run for 1° drop in temperature. For convenience in calculating, it has been assumed in the following that there is 1° drop in every 20 ft. of run and the temperature at the fan is assumed as 120° F.; thus, the air 20 ft. from fan would be 119° F., at 40 ft., 118°, etc.

The formula to obtain the quantity of air for any given B. T. U. loss per hour is:

$$\text{Cubic feet per minute equals } \frac{\text{B. T. U.}}{60\ (T\text{-}t)\ DS}$$

When B. T. U. = heat required in B. T. U. per hour.
T = temperature F. of entering air.
t. = temperature F. of room air.
D = density of entering air at temperature T.
S = specific heat of air.
60 = number of minutes in an hour.

If the heat loss in each room is exactly equal to the heat brought in by the 1500 cu. ft. of air at 120° F. and 70° F. is the room temperature the heating requirement is

$$\frac{1500 \times (120 - 70) \times 60}{60} \text{ or } \frac{1500 \times 50 \times 60}{60} = \frac{4500000}{60} = 75000 \text{ B.T.U.}$$

60 being the number of cubic feet 1 B. T.U. will raise 1° at 120° (temperature T).

Then by substituting, the C.F.M. (for any outlet where the B.T.U. loss is 75000 B. T. U.) will equal:

$$\frac{75000}{60 \times (T\text{-}t) \times 0.0685 \times 0.2375}$$

At 1° drop in temperature every 20 ft. the temperature at the outlets at the end of duct will be

A = 119°
B = 118°
C = 117°
F = 114°
G = 113°
H = 112°
K = 114½°
M = 113½°
O = 112½°
Q = 111½°

$$A = \frac{75000}{60 \times (119\text{-}70) \times 0.0685 \times 0.2375}$$

(Continued on Sheet No. 10-S)

METHOD NO. 5—Continued.

(Concluded from Sheet No. 10-R)

The fall in temperature is so slight in any one system that to save computation

$$\frac{75000}{60 \times 0.0685 \times 0.2375}$$

may be reduced to a constant, which divided by (T-t) will equal C. F. M. This reduces to

$$\frac{75000}{0.976125} \text{ or } 76940$$

Then

$$A = \frac{76940}{119-70} \times 2, \text{ or } \frac{76940}{49} \times 2, \text{ or } 1570 \times 2 = 3140$$

$$B = \frac{76940}{118-70} \times 2, \text{ or } 1603 \times 2 = 3206$$

$$C = \frac{76940}{117-70} \times 2, \text{ or } 1637 \times 2 = 3274$$

$$F = \frac{76940}{114-70} \times 2, \text{ or } 1748 \times 2 = 3496$$

$$G = \frac{76940}{113-70} \times 2, \text{ or } 1789 \times 2 = 4578$$

Then

$$H = \frac{76940}{112-70} \times 2, \text{ or } 1832 \times 2 = 3664$$

$$K = \frac{76940}{114\tfrac{1}{2}-70} = 1729$$

$$M = \frac{76940}{113\tfrac{1}{2}-70} = 1769$$

$$O = \frac{76940}{112\tfrac{1}{2}-70} = 1810$$

$$Q = \frac{76940}{111\tfrac{1}{2}-70} = 1854$$

The total air to be delivered by the fan is the sum of these totals, or

A 3,140, B 3,206, C 3,274, F 3,496, G 3,578, H 3,664, K 1,729, M 1,769, O 1,810, Q 1,854. Total 27,520 C. F. M.

The same steel plate fan previously considered will deliver the required amount of air and, as previously noted, its outlet is 42 in. x 42 in. or equivalent to 11,432 1-in. pipes. Then the

$$\frac{11432}{27520} = 0.415$$

Say 0.42, the number of 1-in. square pipes to be allowed to each cubic foot of air per minute, this being called the factor (F). This factor, however, is usually made from 0.6 for shorter systems to 0.7 for longer systems to avoid excessive friction losses and high velocities. If 0.6 is used:

C.M.F.		F.		1-in. Sq. Pipes
3140	x	0.6	=	1884
3206	x	0.6	=	1924
3274	x	0.6	=	1964
3496	x	0.6	=	2098
3578	x	0.6	=	2147
3664	x	0.6	=	2198
1729	x	0.6	=	1037
1769	x	0.6	=	1061
1810	x	0.6	=	1086
1854	x	0.6	=	1112

Duct sizes with allowance for temperature drop, Method No. 5.

H = 2198, or 21 in. x 22 in. = 462 sq. in. of duct.
G = 2198 + 2147 = 4345, or 28 in. x 29 in. = 812 sq. in. of duct.
E and F = 4345 + 2098 = 6443, or 33 in. x 34 in. = 1122 sq. in. of duct.
P and Q = 1112, or 17 in. x 17 in. = 289 sq. in. of duct.
O and N = 1112 + 1086 = 2198, or 21 in. x 22 in. = 462 sq. in. of duct.
M and L = 2198 + 1061 = 3259, or 25 in. x 26 in. = 650 sq. in. of duct.
K and J = 3259 + 1037 = 4296, or 28 in. x 28 in. = 784 sq. in. of duct.
E and J = 4296 + 6443 = 10739, or 40 in. x 41 in. = 1640 sq. in. of duct.
C = 10739 + 1964 = 12703, or 44 in. x 44 in. = 1936 sq. in. of duct.
B = 12703 + 1924 = 14627, or 46 in. x 46 in. = 2116 sq. in. of duct.
A = 14627 + 1884 = 16511, or 49 in. x 49 in. = 2401 sq. in. of duct.

It can readily be seen that the proper quantity of air will be delivered to maintain the heat equilibrium and that the duct friction is kept at a fairly constant point, although not quite constant, as no allowance is made for bends, transformations, etc., and while the duct sizes thus obtained increase toward the far end of the system it is only because they are expected to handle a greater quantity of air at the same friction loss per foot of duct in order to compensate for temperature drop in the duct.

SIZING DUCTS AND FLUES.
METHOD NO. 6

NOTE—For explanation and example assumed see Standard Data Sheets Nos. 10-M and 10-N.

The Buffalo Forge Co. utilizes two methods for sizing ducts and flues, one system for industrial work and another for public buildings.

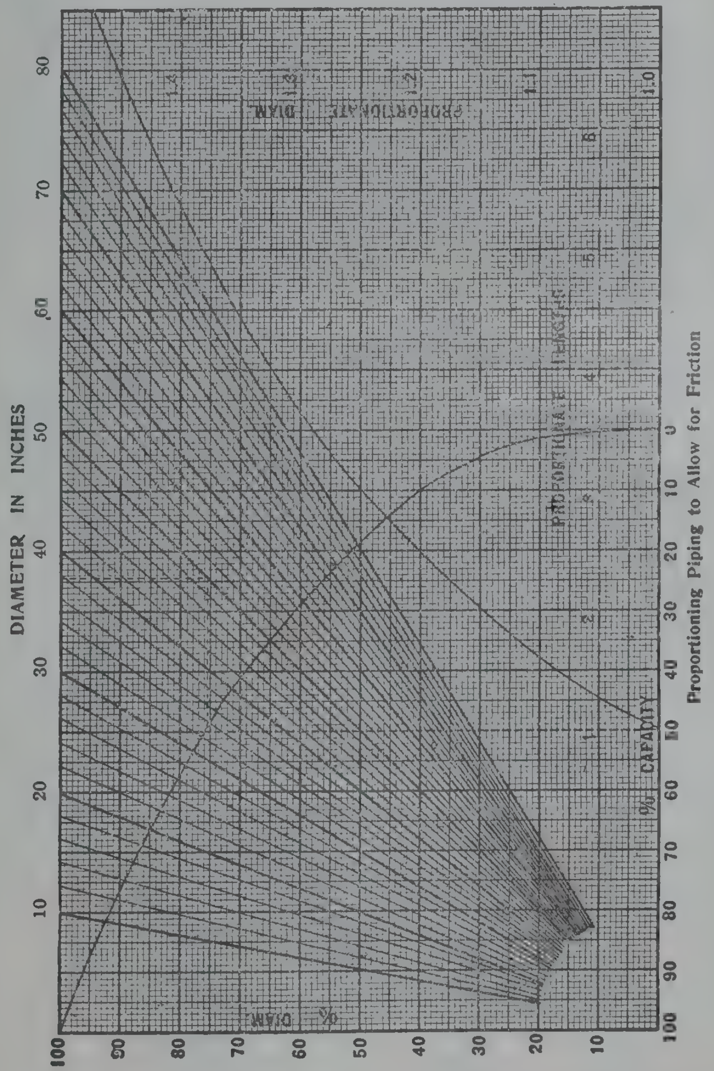


FIG. 1.—CHART FOR FIGURING DUCT AND FLUE SIZES ACCORDING TO METHOD NO. 6

SIZING DUCTS AND FLUES.

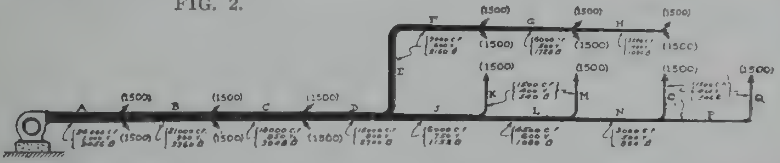
Method No. 6—Continued.

In public building work, individual ducts are recommended similar to those described in Method No. 2. For industrial buildings the sizing is developed from a chart which gives a constant friction drop in all lines regardless of size.

To use the chart, shown in Fig. 1, it is only necessary to determine the percentage of air delivered to each outlet and carried by each duct, together with the size of duct at the fan outlet; the sizes can then be read directly from the chart as follows:—

In the typical layout being used as an example, the total air is 24,000 cu. ft. per minute; allowing an additional 10% for losses in the system it is found from the chart that a No. 9 Niagara Conoidal fan is the proper size and that this fan has an outlet area of 11.81 sq. ft. The duct leaving the fan should have an area equal to, or slightly greater than the outlet; assuming, in this case, a 46-in. diameter duct (area of 11.54 sq. ft.), all the other sizes are determined from this basic size, these being governed by the percentage of air handled in each case.

FIG. 2.



The percentage of air for each of sixteen equal outlets is 6¼% per outlet and this gives the percentages for each case as shown in Fig. 2. For instance, after the first pair of outlets is taken off the main duct, 87½% of the air is left; finding 87½ on bottom of chart and following this up to the point where it intersects with the curve the per cent of diameter may be read in the left-hand column (95%) 46-in. x 95% = 43.7-in., or 44-in. diameter duct. To read the size directly, instead of going to the left from the intersection go to the right until the diagonal line for the original flue size (46-in.) is met. Vertically above this second intersection may be read the size of the flue which will carry 87½ of the volume at the same drop as the 46-in. diameter duct (or 44-in.) which agrees with the size obtained by the longer method of multiplying the 46-in. diameter by 95%.

Continuing this method for the other percentages gives the duct sizes shown in Fig. 2, from which the velocities (when desired) may be computed, these being in this case as indicated.

This gives a schedule of sizes as follows:—

Duct or Flue Mark	Quantity of Air C. F. M.	Proportion of Total P. C.	Diam. of Pipe Inches	Area of Pipe Sq. Ft.	Velocity in Pipe F. P. M.
A	24,000	100	46	11.54	2080
B	21,000	87½	44	10.56	1980
C	18,000	75	41	9.17	1960
D	15,000	62½	38	7.87	1900
E-F	9,000	37½	32	5.58	1610
G	6,000	25	26	3.69	1620
H	3,000	12½	19	1.97	1520
J	6,000	25	26	3.69	1620
L	4,500	18¾	23	2.88	1560
N	3,000	12½	19	1.97	1520
K-M-O-P-Q	1,500	6¼	15	1.23	1220

SIZING OF DUCTS AND FLUES—METHOD NO. 7.

(B. F. Sturtevant Co.)

NOTE.—For explanation and example assumed see Standard Data Sheets Nos. 10-M and 10-N.

The Sturtevant Co. uses a method of sizing ducts and flues based on equivalent pipes—usually 5-in. pipes being used. For school house and public building work velocities are used ranging from 1000 ft. per minute minimum to 1500 ft. per minute maximum. For the example here assumed a velocity at the fan of 1000 ft. per minute has been adopted, although for factory buildings this velocity is increased to 2000 to 2400 ft. per minute.

In this system there are sixteen outlets each to deliver 1500 C.F.M. This gives a total volume of 24,000 C.F.M. With a velocity of 1000 ft. per minute, the area of the pipe at the fan outlet would be 24 sq. ft., or 3456 sq. in. The next size round pipe to this would be 66 in. in diameter. In practice a pipe is used whose diameter is an even number of inches, that is, fractional sizes are disregarded. While not absolutely accurate, this method is close enough because two different men, building the same size of pipe would vary the friction considerably, depending upon the care which they used in forming the joints.

The equivalent 5-in. pipes for ducts and flues of various diameters shown herewith in Table I.

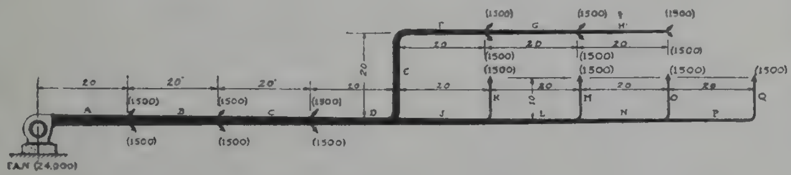
TABLE

Diam. of Pipe In.	Equiv. 5in. diam. Pipes	Diam. of Pipe In.	Equiv. 5in. diam. Pipes	Diam. of Pipe In.	Equiv. 5in. diam. Pipes	Diam. of Pipe In.	Equiv 5in. diam Pipes
5	1	29	79	53	365	77	931
6	1.6	30	88	54	378	78	961
7	2.3	31	96	55	400	79	992
8	3.2	32	103	56	414	80	1024
9	4.3	33	109	57	444	81	1056
10	5.7	34	119	58	458	82	1089
11	7	35	127	59	475	83	1122
12	9	36	138	60	499	84	1156
13	11	37	146	61	514	85	1191
14	13	38	157	62	538	86	1226
15	16	39	170	63	560	87	1262
16	18	40	179	64	587	88	1298
17	21	41	191	65	604	89	1336
18	24	42	204	66	630	90	1374
19	28	43	215	67	658	91	1413
20	32	44	228	68	678	92	1452
21	35	45	240	69	708	93	1492
22	41	46	253	70	730	94	1532
23	47	47	269	71	763	95	1573
24	50	48	282	72	786	96	1615
25	55	49	298	73	814	97	1657
26	62	50	316	74	843	98	1707
27	68	51	329	75	871	99	1744
28	74	52	349	76	901	100	1788

SIZING DUCTS AND FLUES—SEVENTH METHOD (Continued).

From this table it is seen that a 66-in. pipe is equivalent to 630-5-in. pipes. 24,000 C. F. M. ÷ 630 = 38 cu. ft. per 5-in. pipe, equivalent to 1500/38 = 39.5 5-in. pipes, the required size of each outlet. From the table it is seen that it is very nearly equal to a 22-in. pipe. The equivalent number of 5-in. pipes for two outlets would be 79; for 3 outlets, 118½; for 4 outlets, 158; for 5 outlets, 197½; for 6 outlets, 237; for 7 outlets, 276½; for 8 outlets, 316; for 9 outlets, 355½; for 10 outlets, 395; for 11 outlets, 434½; for 12 outlets, 474; fr 13 outlets, 513½; for 14 outlets, 553; for 15 outlets, 592½.

This gives a schedule of duct and flue sizes as follows:



SIZES BY METHOD NO. 7.

Direct or Flue	Length	Cu.ft. per Min.	Dia. in.	Area sq. in.	Velocity ft per. min.
A	Immaterial	24000	66	3420	1050
B	"	21000	63	3100	975
C	"	18000	59	2720	950
D	"	15000	55	2370	915
E & F	"	9000	45	1580	820
G & J	"	6000	38	1130	760
H	"	3000	29	660	650
L	"	4500	34	910	710
N	"	3000	29	660	650
K-M-O-Q	"	1500	22	380	570

All outlets 22 in. in diameter.

SUPPLY AND EXHAUST OUTLETS.

While there are many different methods of making flue connections to supply and exhaust outlets, the simplest satisfactory connections are shown in Figs. 1 and 2.

In Fig. 1 is illustrated an up-feed supply system outlet in which the vertical flue is carried a slight distance above the top of the outlet in order to form an air cushion and to help equalize the air flow across the register face. This distance—which is usually made 8 in. to 12 in.—does not absolutely equalize the air flow but tends to prevent such a large quantity of air shooting out through the top third of the register as would be the case if a plain elbow were used.

The volume damper is an ordinary wing damper one end of which is attached to a wire held by the set screw. It is necessary to have the register face either hinged or to set the volume dampers before the installation of the registers. Many engineers prefer their volume dampers set at other points in the duct system to avoid this difficulty, but it must be admitted that an outlet can be set more quickly from anemometer readings when the damper is at the outlet than when it is off in some other part of the building.

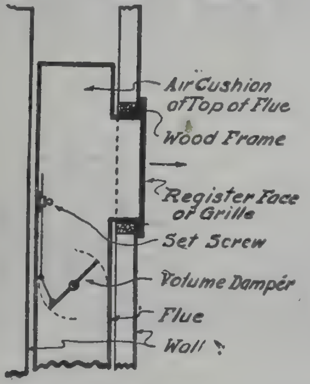


FIG. 1

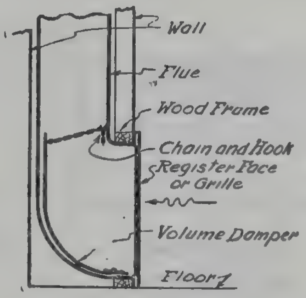


FIG. 2.

Fig. 2 illustrates a similar outlet for an up-feed exhaust system with a volume damper consisting of a piece of curved sheet metal riveted to the flue at the bottom and hooked to the proper position at the top by means of the chain and hook shown. The spring of the metal will hold this damper tightly in its proper place after being adjusted. To operate this damper a hinged or removable register must be used and for this reason some engineers prefer controlling air in the flue from a damper located in the horizontal duct connecting to the top of the flue.

In all cases it has been found advantageous to have the wood frame made around the flue outlet in the shop; this protects the outlet during shipping, handling and erection, keeping it in proper shape and preventing bending and dents. After the flues are erected the wooden frames have wall ties nailed to them and are walled in; the furring strips are run around the edge and the wall plastered, after which the registers or grilles are mounted by attaching them to the metal, or by screwing through the furring into the solid wood of frame.

REVERSING DAMPERS.

In many buildings it is considered desirable to put the warm air in at the upper openings during the winter, drawing the cold air out of the lower exhaust openings at the floor, while in summer it is preferred to draw the hot air at the ceiling off through the upper openings and putting the cold air in through the lower openings. In other cases it may be desirable to use upward ventilation (supply openings low and exhaust openings high) whenever cigar smoke is to be handled, and downward ventilation (supply openings high and exhaust openings low) at all other times.

In the ordinary duct system such a reversal is impossible, but in cases where the supply and exhaust fans are set close together, or where the main supply and exhaust ducts run near each other, it is possible to provide for such conditions by the proper arrangement of one or more dampers.

The single reversing damper is shown in Fig. 1, the duct E being connected to the suction opening of the exhaust fan, the duct S to the discharge opening of the supply fan, the duct U to the upper openings in the building and the duct L to the lower openings in the building. It is self-evident that the turning of the damper from the position shown in full lines to the position shown in dotted lines will reverse the flow of air in both the ducts U and L. The ducts coming into such a damper must all be of the same size and dimensions, the height H of the damper being the same as the height of the duct. The radius of the damper casing r is equal to the width of the duct D, plus a few inches (to allow for the construction in the middle of the damper). The damper radius R is equal to 2r or twice that of the casing.

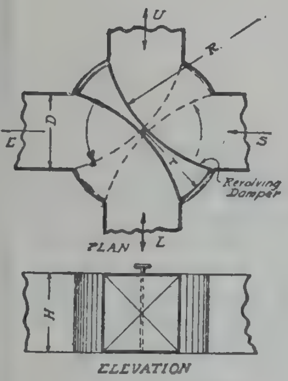


FIG. 1.

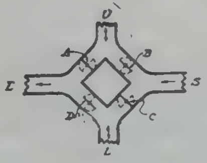


FIG. 2.

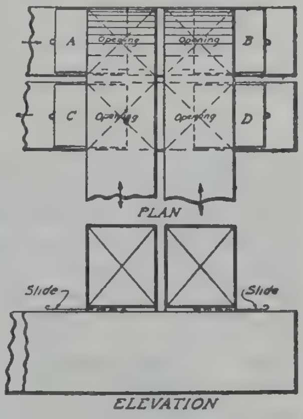
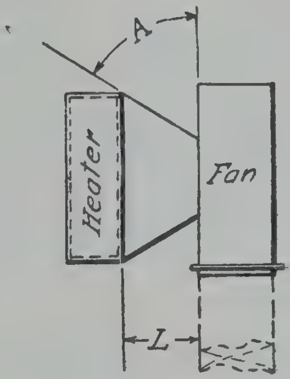


FIG. 3.

A second method, where the ducts are not on the same level, is shown in Fig. 2. Here the opening of slides A and D closing B and C or the opening B and C and the closing of A and D will reverse the flow in the ducts U and L.

A third method is shown in Fig. 3, where the opening of dampers A and C and the closing of B and D will reverse the flow in ducts U and L from what it would be with B and D open and A and C closed.

DISTANCE BETWEEN FAN AND HEATER.



In a draw-through arrangement the minimum allowable distance between the fan inlet and the end of the heater is a most important item. If this distance is made too short and the transformation from the shape and size of the heater outlet down to the shape and size of the fan inlet becomes too abrupt, serious results may follow. Of course the sharp transformation tends to produce eddy currents and thus increase the friction against which the fan must operate, but this is not the most objectionable feature resulting.

When a connection of this kind is too short the air tends to follow a straight line which may be drawn from the side of the heater inlet to the circumference of the fan inlet and will thus short-circuit a large part of the heater near the outlet all around the outside of the heater.

The United States Government recommends that the angle A, as shown in the illustration should be not less than 60° in order to avoid this difficulty, while the Buffalo Forge Company gives the following schedule:

Size of Fan. Inches.	Length L. Inches.
Up to 70	18 to 24
70 to 100	24 to 30
100 to 130	36
130 to 170	42
170 to 200	48 to 54

TABLES FOR VENTILATING DUCTS

The accompanying tables (Nos. 11-E to 11-J, inclusive) give the superficial area and weights of galvanized sheet-iron rectangular ducts. The tables, six in number, embrace all sizes from 1 in. up to 60 in. square.

In the central portion of each table are placed the cross-sectional dimensions of the ducts in inches, those in the first (or the last) column representing one dimension and the intervening quantities the other dimension. The latter are so arranged that all sizes of ducts having the same circumference appear in the same vertical column and, therefore, have the same superficial area per lineal foot of length.

The inclined line divides the two portions of the table so as to utilize the whole form, and the resulting quantities are read either up or down, according to which side of this line the second dimension of the duct occurs.

For example referring to Data Sheet No. 11-E for 8 in. x 10 in., the latter dimension will be found on the other side of the inclined line, and the resulting quantities are obtained by reading downward in the column in which 18 appears, in the same manner as before.

The quantities given under caption, "Square Feet per Lineal Foot" are for actual outside surface and are useful when calculating painting, non-conducting coverings and the like. The quantities given under "Weight per Lineal Foot," however, have allowances made for seams and are all based on the assumption that ducts are cut from 30 in. wide sheets and that one lap of 1 in. is required for each sheet so used. In other words, ducts up to 29-in. circumference allow one lapping inch; from 30-in. to 59-in., two lapping inches, and so on up to 60-in. x 60-in., which having 240 in. circumference are allowed 9 lapping inches in the table of weights.

No attempt has been made to allow for waste material, bracing or hanging and some percentage should be added to the tabulated quantities to take care of these. For ordinary purposes, 10% to 15% will be found sufficient, but obviously no exact rule can be laid down, on account of the varying conditions of practice.

TABLES FOR VENTILATING DUCTS.

Superficial Area and Weight of Galvanized Sheet Iron Rectangular Ducts.

Wt. p. □'	2.7#	2.2#	1.7#	1.5#	1.2#	1.0#	□' Per Lin Ft	CROSS SECTIONAL DIMENSIONS OF DUCTS IN INCHES																				□' Per Lin Ft	1.0#	1.2#	1.5#	1.7#	2.2#	2.7#	Wt. p. □'
Gauge	#16	#18	#20	#22	#24	#26		20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1		#26	#24	#22	#20	#18	#16	Gauge
WEIGHT OF GALVANIZED IRON RECTANGULAR DUCTS PER LINEAL FOOT	10.35	8.43	6.52	5.75	4.60	3.83	3.67	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20									WEIGHT OF GALVANIZED IRON RECTANGULAR DUCTS PER LINEAL FOOT
	10.80	8.80	6.80	6.00	4.80	4.00	3.83	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20		1	.33	.42	.50	.63	.71	.92	1.13	
	11.25	9.17	7.08	6.25	5.00	4.17	4.00	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20		1	2	.50	.58	.70	.88	.99	1.28	1.58	
	11.70	9.53	7.37	6.50	5.20	4.33	4.17	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20		1	2	3	.67	.75	.90	1.13	1.28	1.65	2.03	
	12.15	9.90	7.65	6.75	5.40	4.50	4.33	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20		1	2	3	4	.83	.92	1.10	1.38	1.56	2.02	2.48	
	12.60	10.27	7.93	7.00	5.60	4.67	4.50	7	8	9	10	11	12	13	14	15	16	17	18	19	20		1	2	3	4	5	1.00	1.08	1.30	1.63	1.84	2.38	2.93	
	13.05	10.63	8.22	7.25	5.80	4.83	4.67	8	9	10	11	12	13	14	15	16	17	18	19	20		1	2	3	4	5	6	1.17	1.25	1.50	1.88	2.13	2.75	3.38	
	13.50	11.00	8.50	7.50	6.00	5.00	4.83	9	10	11	12	13	14	15	16	17	18	19	20		1	2	3	4	5	6	7	1.33	1.42	1.70	2.13	2.41	3.12	3.83	
	14.15	11.65	8.93	7.88	6.30	5.25	5.00	10	11	12	13	14	15	16	17	18	19	20		1	2	3	4	5	6	7	8	1.50	1.58	1.90	2.38	2.69	3.48	4.28	
	14.63	11.92	9.21	8.13	6.50	5.42	5.17	11	12	13	14	15	16	17	18	19	20		1	2	3	4	5	6	7	8	9	1.67	1.75	2.10	2.63	2.98	3.85	4.73	
	15.08	12.28	9.49	8.38	6.70	5.58	5.33	12	13	14	15	16	17	18	19	20		1	2	3	4	5	6	7	8	9	10	1.83	1.92	2.80	2.88	3.26	4.22	5.18	
	15.53	12.65	9.78	8.63	6.90	5.75	5.50	13	14	15	16	17	18	19	20		1	2	3	4	5	6	7	8	9	10	11	2.00	2.08	2.50	3.13	3.54	4.58	5.63	
	15.98	13.07	10.06	8.88	7.10	5.92	5.67	14	15	16	17	18	19	20		1	2	3	4	5	6	7	8	9	10	11	12	2.17	2.25	2.70	3.38	3.83	4.95	6.08	
	16.43	13.38	10.34	9.13	7.30	6.08	5.83	15	16	17	18	19	20		1	2	3	4	5	6	7	8	9	10	11	12	13	2.33	2.42	2.90	3.63	4.11	5.32	6.53	
	16.88	13.75	10.63	9.38	7.50	6.25	6.00	16	17	18	19	20		1	2	3	4	5	6	7	8	9	10	11	12	13	14	2.50	2.67	3.20	4.00	4.53	5.87	7.20	
	17.33	14.12	10.91	9.63	7.70	6.42	6.17	17	18	19	20		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	2.67	2.83	3.40	4.25	4.82	6.23	7.65	
	17.78	14.48	11.19	9.88	7.90	6.58	6.33	18	19	20		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	2.83	3.00	3.60	4.50	5.10	6.60	8.10	
	18.23	14.85	11.48	10.13	8.10	6.75	6.50	19	20		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	3.00	3.17	3.80	4.75	5.38	6.97	8.55	
	18.68	15.22	11.76	10.38	8.30	6.92	6.67	20		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	3.17	3.33	4.00	5.00	5.67	7.33	9.00	
									1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	3.33	3.50	4.20	5.25	5.95	7.70	9.45	
								1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	3.50	3.67	4.40	5.50	6.23	8.07	9.90	
Gauge	#16	#18	#20	#22	#24	#26	□' Per Lin Ft	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	□' Per Lin Ft	#26	#24	#22	#20	#18	#16	Gauge
Wt. p. □'	2.7#	2.2#	1.7#	1.5#	1.2#	1.0#		CROSS SECTIONAL DIMENSIONS OF DUCTS IN INCHES																					1.0#	1.2#	1.5#	1.7#	2.2#	2.7#	Wt. p. □'

TABLES FOR VENTILATING DUCTS.

Superficial Area and Weight of Galvanized Sheet Iron Rectangular Ducts

WT p ϕ	GAUGE	WEIGHT OF GALVANIZED IRON RECTANGULAR DUCTS PER LINEAL FOOT																					GAUGE	WT p ϕ
2.7#	#16		10.35	10.80	11.25	11.70	12.15	12.60	13.05	13.50	14.18	14.63	15.08	15.53	15.98	16.43	16.88	17.33	17.78	18.23	18.68	19.13	#16	2.7#
2.2#	#18		8.43	8.80	9.17	9.53	9.90	10.27	10.63	11.00	11.55	11.92	12.28	12.65	13.02	13.38	13.75	14.12	14.48	14.85	15.22	15.58	#18	2.2#
1.7#	#20		6.52	6.80	7.08	7.37	7.65	7.93	8.22	8.50	8.93	9.21	9.49	9.78	10.06	10.34	10.63	10.91	11.19	11.48	11.76	12.04	#20	1.7#
1.5#	#22		5.75	6.00	6.25	6.50	6.75	7.00	7.25	7.50	7.88	8.13	8.38	8.63	8.88	9.13	9.38	9.63	9.88	10.13	10.38	10.63	#22	1.5#
1.2#	#24		4.60	4.80	5.00	5.20	5.40	5.60	5.80	6.00	6.30	6.50	6.70	6.90	7.10	7.30	7.50	7.70	7.90	8.10	8.30	8.50	#24	1.2#
1.0#	#26		3.83	4.00	4.17	4.33	4.50	4.67	4.83	5.00	5.25	5.42	5.58	5.75	5.92	6.08	6.25	6.42	6.58	6.75	6.92	7.08	#26	1.0#
ϕ PER LIN FT			3.67	3.83	4.00	4.17	4.33	4.50	4.67	4.83	5.00	5.17	5.33	5.50	5.67	5.83	6.00	6.17	6.33	6.50	6.67	6.83	ϕ PER LIN FT	
CROSS SECTIONAL DIMENSIONS OF DUCTS IN INCHES	1		21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	1	CROSS SECTIONAL DIMENSIONS OF DUCTS IN INCHES
	2	40		21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	2	
	3	39	40		21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	3	
	4	38	39	40		21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	4	
	5	37	38	39	40		21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	5	
	6	36	37	38	39	40		21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	6	
	7	35	36	37	38	39	40		21	22	23	24	25	26	27	28	29	30	31	32	33	34	7	
	8	34	35	36	37	38	39	40		21	22	23	24	25	26	27	28	29	30	31	32	33	8	
	9	33	34	35	36	37	38	39	40		21	22	23	24	25	26	27	28	29	30	31	32	9	
	10	32	33	34	35	36	37	38	39	40		21	22	23	24	25	26	27	28	29	30	31	10	
	11	31	32	33	34	35	36	37	38	39	40		21	22	23	24	25	26	27	28	29	30	11	
	12	30	31	32	33	34	35	36	37	38	39	40		21	22	23	24	25	26	27	28	29	12	
	13	29	30	31	32	33	34	35	36	37	38	39	40		21	22	23	24	25	26	27	28	13	
	14	28	29	30	31	32	33	34	35	36	37	38	39	40		21	22	23	24	25	26	27	14	
	15	27	28	29	30	31	32	33	34	35	36	37	38	39	40		21	22	23	24	25	26	15	
	16	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40		21	22	23	24	25	16	
	17	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40		21	22	23	24	17	
	18	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40		21	22	23	18	
	19	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40		21	22	19	
	20	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40		21	20	
ϕ PER LIN FT		7.00	7.17	7.33	7.50	7.67	7.83	8.00	8.17	8.33	8.50	8.67	8.83	9.00	9.17	9.33	9.50	9.67	9.83	10.00			ϕ PER LIN FT	
10#	#26	7.25	7.42	7.58	7.83	8.00	8.17	8.33	8.50	8.67	8.83	9.00	9.17	9.33	9.50	9.67	9.83	10.00	10.17	10.42			#26	10#
12#	#24	8.70	8.90	9.10	9.40	9.60	9.80	10.00	10.20	10.40	10.60	10.80	11.00	11.20	11.40	11.60	11.80	12.00	12.20	12.50			#24	12#
15#	#22	10.88	11.13	11.38	11.75	12.00	12.25	12.50	12.75	13.00	13.25	13.50	13.75	14.00	14.25	14.50	14.75	15.00	15.25	15.63			#22	1.5#
17#	#20	12.33	12.61	12.89	13.32	13.60	13.88	14.17	14.45	14.73	15.02	15.30	15.58	15.87	16.15	16.43	16.72	17.00	17.28	17.71			#20	17#
2.2#	#18	15.95	16.32	16.68	17.23	17.60	17.97	18.33	18.70	19.07	19.43	19.80	20.17	20.53	20.90	21.27	21.63	22.00	22.37	22.92			#18	2.2#
2.7#	#16	19.58	20.03	20.48	21.15	21.60	22.05	22.50	22.95	23.40	23.85	24.30	24.75	25.20	25.65	26.10	26.55	27.00	27.45	28.13			#17	2.7#
WT p ϕ	GAUGE	WEIGHT OF GALVANIZED IRON RECTANGULAR DUCTS PER LINEAL FOOT																					GAUGE	WT p ϕ

TABLES FOR VENTILATING DUCTS.

Superficial Area and Weight of Galvanized Sheet Iron Rectangular Ducts.

WT. P □	GAUGE	WEIGHT OF GALVANIZED IRON RECTANGULAR DUCTS PER LINEAL FOOT																					GAUGE	WT. P □
2.7#	#16		19.58	20.03	20.48	21.15	21.60	22.05	22.50	22.95	23.40	23.85	24.30	24.75	25.20	25.65	26.10	26.55	27.00	27.45	28.13	28.58	#16	2.7#
2.2#	#18		15.95	16.32	16.68	17.23	17.60	17.97	18.33	18.70	19.07	19.43	19.80	20.17	20.53	20.90	21.27	21.63	22.00	22.37	22.92	23.28	#18	2.2#
1.7#	#20		12.33	12.61	12.89	13.32	13.60	13.88	14.17	14.45	14.73	15.02	15.30	15.58	15.87	16.15	16.43	16.72	17.00	17.28	17.71	17.99	#20	1.7#
1.5#	#22		10.88	11.13	11.38	11.75	12.00	12.25	12.50	12.75	13.00	13.25	13.50	13.75	14.00	14.25	14.50	14.75	15.00	15.26	15.63	15.88	#22	1.5#
1.2#	#24		8.70	8.90	9.10	9.40	9.60	9.80	10.00	10.20	10.40	10.60	10.80	11.00	11.20	11.40	11.60	11.80	12.00	12.20	12.50	12.70	#24	1.2#
1.0#	#26		7.25	7.42	7.58	7.83	8.00	8.17	8.33	8.50	8.67	8.83	9.00	9.17	9.33	9.50	9.67	9.83	10.00	10.17	10.42	10.58	#26	1.0#
□ PER LIN FT.			7.00	7.17	7.33	7.50	7.67	7.83	8.00	8.17	8.33	8.50	8.67	8.83	9.00	9.17	9.33	9.50	9.67	9.83	10.00	10.17	□ PER LIN. FT.	
CROSS SECTIONAL DIMENSIONS OF DUCTS IN INCHES	1		41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	1	CROSS SECTIONAL DIMENSIONS OF DUCTS IN INCHES
	2	60		41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	2	
	3	59	60		41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	3	
	4	58	59	60		41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	4	
	5	57	58	59	60		41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	5	
	6	56	57	58	59	60		41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	6	
	7	55	56	57	58	59	60		41	42	43	44	45	46	47	48	49	50	51	52	53	54	7	
	8	54	55	56	57	58	59	60		41	42	43	44	45	46	47	48	49	50	51	52	53	8	
	9	53	54	55	56	57	58	59	60		41	42	43	44	45	46	47	48	49	50	51	52	9	
	10	52	53	54	55	56	57	58	59	60		41	42	43	44	45	46	47	48	49	50	51	10	
	11	51	52	53	54	55	56	57	58	59	60		41	42	43	44	45	46	47	48	49	50	11	
	12	50	51	52	53	54	55	56	57	58	59	60		41	42	43	44	45	46	47	48	49	12	
	13	49	50	51	52	53	54	55	56	57	58	59	60		41	42	43	44	45	46	47	48	13	
	14	48	49	50	51	52	53	54	55	56	57	58	59	60		41	42	43	44	45	46	47	14	
	15	47	48	49	50	51	52	53	54	55	56	57	58	59	60		41	42	43	44	45	46	15	
	16	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60		41	42	43	44	45	16	
	17	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60		41	42	43	44	17	
	18	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60		41	42	43	18	
	19	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60		41	42	19	
	20	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60		41	20	
□ PER LIN FT.		10.33	10.50	10.67	10.83	11.00	11.17	11.33	11.50	11.67	11.83	12.00	12.17	12.33	12.50	12.67	12.83	13.00	13.17	13.33			□ PER LIN FT	
1.0#	#26	10.75	10.92	11.08	11.25	11.42	11.59	11.75	11.92	12.08	12.25	12.42	12.58	12.75	13.00	13.17	13.33	13.50	13.67	13.83			#26	1.0#
1.2#	#24	12.90	13.10	13.30	13.50	13.70	13.90	14.10	14.30	14.50	14.70	14.90	15.10	15.30	15.60	15.80	16.00	16.20	16.40	16.60			#24	1.2#
1.5#	#22	16.13	16.38	16.63	16.88	17.13	17.38	17.63	17.88	18.13	18.38	18.63	18.88	19.13	19.50	19.75	20.00	20.25	20.50	20.75			#22	1.5#
1.7#	#20	18.28	18.56	18.84	19.13	19.41	19.69	19.98	20.26	20.54	20.83	21.11	21.39	21.68	22.10	22.38	22.67	22.95	23.23	23.52			#20	1.7#
2.2#	#18	23.65	24.02	24.38	24.75	25.12	25.48	25.85	26.22	26.58	26.95	27.32	27.68	28.05	28.60	28.97	29.33	29.70	30.07	30.43			#18	2.2#
2.7#	#16	29.03	29.48	29.93	30.38	30.83	31.28	31.73	32.18	32.63	33.08	33.53	33.98	34.43	35.10	35.55	36.00	36.45	36.90	37.35			#16	2.7#
WT. P □	GAUGE	WEIGHT OF GALVANIZED IRON RECTANGULAR DUCTS PER LINEAL FOOT																					GAUGE	WT. P □

TABLES FOR VENTILATING DUCTS.

Superficial Area and Weight of Galvanized Sheet Iron Rectangular Ducts.

WT. P. □	27#	22#	17#	15#	12#	10#	□ PER LIN FT	CROSS SECTIONAL DIMENSIONS OF DUCTS IN INCHES																				□ PER LIN FT	10#	12#	15#	17#	22#	27#	WT. P. □
GAUGE	#16	#18	#20	#22	#24	#26		40	39	38	37	36	35	34	33	32	31	30	29	28	27	26	25	24	23	22	21		#26	#24	#22	#20	#18	#16	GAUGE
WEIGHT OF GALVANIZED IRON RECTANGULAR DUCTS PER LINEAL FOOT	29.03	23.65	18.28	16.13	12.90	10.75	10.33	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40									WEIGHT OF GALVANIZED IRON RECTANGULAR DUCTS PER LINEAL FOOT
	29.48	24.02	18.56	16.38	13.10	10.92	10.50	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40		21	7.00	7.25	8.70	10.88	12.33	15.95	19.58	
	29.93	24.38	18.84	16.63	13.30	11.08	10.67	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40		21	22	7.17	7.42	8.90	11.13	12.61	16.32	20.03	
	30.38	20.75	19.13	16.88	13.50	11.25	10.83	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40		21	22	23	7.33	7.58	9.10	11.38	12.89	16.68	20.48	
	30.83	25.12	19.41	17.13	13.70	11.42	11.00	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40		21	22	23	24	7.50	7.83	9.40	11.75	13.32	17.23	21.15	
	31.28	25.48	19.69	17.38	13.90	11.58	11.17	27	28	29	30	31	32	33	34	35	36	37	38	39	40		21	22	23	24	25	7.67	8.00	9.60	12.00	13.60	17.60	21.60	
	31.73	25.85	19.98	17.63	14.10	11.75	11.33	28	29	30	31	32	33	34	35	36	37	38	39	40		21	22	23	24	25	26	7.83	8.17	9.80	12.25	13.88	17.97	22.05	
	32.18	26.22	20.26	17.88	14.30	11.92	11.50	29	30	31	32	33	34	35	36	37	38	39	40		21	22	23	24	25	26	27	8.00	8.33	10.00	12.50	14.17	18.33	22.50	
	32.63	26.58	20.54	18.13	14.50	12.08	11.67	30	31	32	33	34	35	36	37	38	39	40		21	22	23	24	25	26	27	28	8.17	8.50	10.20	12.75	14.45	18.70	22.95	
	33.08	26.95	20.83	18.38	14.70	12.25	11.83	31	32	33	34	35	36	37	38	39	40		21	22	23	24	25	26	27	28	29	8.33	8.67	10.40	13.00	14.73	19.07	23.40	
	33.53	27.32	21.11	18.63	14.90	12.42	12.00	32	33	34	35	36	37	38	39	40		21	22	23	24	25	26	27	28	29	30	8.50	8.83	10.60	13.25	15.02	19.43	23.85	
	33.98	27.68	21.39	18.88	15.10	12.58	12.17	33	34	35	36	37	38	39	40		21	22	23	24	25	26	27	28	29	30	31	8.67	9.00	10.80	13.50	15.30	19.80	24.30	
	34.43	28.05	21.68	19.13	15.30	12.75	12.33	34	35	36	37	38	39	40		21	22	23	24	25	26	27	28	29	30	31	32	8.83	9.17	11.00	13.75	15.58	20.17	24.75	
	35.10	28.60	22.10	19.50	15.60	13.00	12.50	35	36	37	38	39	40		21	22	23	24	25	26	27	28	29	30	31	32	33	9.00	9.33	11.20	14.00	15.87	20.53	25.20	
	35.55	28.97	22.38	19.75	15.80	13.17	12.67	36	37	38	39	40		21	22	23	24	25	26	27	28	29	30	31	32	33	34	9.17	9.50	11.40	14.25	16.15	20.90	25.65	
	36.00	29.33	22.67	20.00	16.00	13.33	12.83	37	38	39	40		21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	9.33	9.67	11.60	14.50	16.43	21.27	26.10	
	36.45	29.70	22.95	20.25	16.20	13.50	13.00	38	39	40		21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	9.50	9.83	11.80	14.75	16.72	21.63	26.55	
	36.90	30.07	23.23	20.50	16.40	13.67	13.17	39	40		21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	9.67	10.00	12.00	15.00	17.00	22.00	27.00	
	37.35	30.43	23.52	20.75	16.60	13.83	13.33	40		21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	9.83	10.17	12.20	15.25	17.28	22.37	27.45	
									21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	10.00	10.42	12.50	15.63	17.71	22.92	28.13	
								21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	10.17	10.58	12.70	15.88	17.99	23.28	28.58	
GAUGE	#16	#18	#20	#22	#24	#26	□ PER LIN FT	40	39	38	37	36	35	34	33	32	31	30	29	28	27	26	25	24	23	22	21	□ PER LIN FT	#26	#24	#22	#20	#18	#16	GAUGE
WT. P. □	27#	22#	17#	15#	12#	10#		CROSS SECTIONAL DIMENSIONS OF DUCTS IN INCHES																					10#	12#	15#	17#	22#	27#	WT. P. □

TABLES FOR VENTILATING DUCTS.

Superficial Area and Weight of Galvanized Sheet Iron Rectangular Ducts.

Wt.p.Φ	Gauge	WEIGHT OF GALVANIZED IRON RECTANGULAR DUCTS PER LINEAL FOOT																					Gauge	Wt.p.Φ
27#	#16		29.03	29.48	29.93	30.38	30.83	31.28	31.73	32.18	32.63	33.08	33.53	33.98	34.43	35.10	35.55	36.00	36.45	36.90	37.25	37.80	#16	27#
22#	#18		23.65	24.02	24.38	24.75	25.12	25.48	25.85	26.22	26.58	26.95	27.32	27.68	28.05	28.60	28.97	29.33	29.70	30.07	30.43	30.80	#18	22#
17#	#20		18.28	18.56	18.84	19.13	19.41	19.69	19.98	20.26	20.54	20.83	21.11	21.39	21.68	22.10	22.38	22.67	22.95	23.23	23.52	23.80	#20	17#
1.5#	#22		16.13	16.38	16.63	16.88	17.13	17.38	17.63	17.88	18.13	18.38	18.63	18.88	19.13	19.50	19.75	20.00	20.25	20.50	20.75	21.00	#22	1.5#
12#	#24		12.90	13.10	13.30	13.50	13.70	13.90	14.10	14.30	14.50	14.70	14.90	15.10	15.30	15.60	15.80	16.00	16.20	16.40	16.60	16.80	#24	12#
10#	#26		10.75	10.92	11.08	11.25	11.42	11.58	11.75	11.92	12.08	12.26	12.42	12.58	12.75	13.00	13.17	13.33	13.50	13.67	13.83	14.00	#26	10#
ΦPer Lin Ft			10.33	10.50	10.67	10.83	11.00	11.17	11.33	11.50	11.67	11.83	12.00	12.17	12.33	12.50	12.67	12.83	13.00	13.17	13.33	13.50	ΦPer Lin Ft	
CROSS SECTIONAL DIMENSIONS OF DUCTS IN INCHES	21		41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	21	CROSS SECTIONAL DIMENSIONS OF DUCTS IN INCHES
	22	60		41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	22	
	23	59	60		41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	23	
	24	58	59	60		41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	24	
	25	57	58	59	60		41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	25	
	26	56	57	58	59	60		41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	26	
	27	55	56	57	58	59	60		41	42	43	44	45	46	47	48	49	50	51	52	53	54	27	
	28	54	55	56	57	58	59	60		41	42	43	44	45	46	47	48	49	50	51	52	53	28	
	29	53	54	55	56	57	58	59	60		41	42	43	44	45	46	47	48	49	50	51	52	29	
	30	52	53	54	55	56	57	58	59	60		41	42	43	44	45	46	47	48	49	50	51	30	
	31	51	52	53	54	55	56	57	58	59	60		41	42	43	44	45	46	47	48	49	50	31	
	32	50	51	52	53	54	55	56	57	58	59	60		41	42	43	44	45	46	47	48	49	32	
	33	49	50	51	52	53	54	55	56	57	58	59	60		41	42	43	44	45	46	47	48	33	
	34	48	49	50	51	52	53	54	55	56	57	58	59	60		41	42	43	44	45	46	47	34	
	35	47	48	49	50	51	52	53	54	55	56	57	58	59	60		41	42	43	44	45	46	35	
	36	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60		41	42	43	44	45	36	
	37	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60		41	42	43	44	37	
	38	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60		41	42	43	38	
	39	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60		41	42	39	
	40	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60		41	40	
ΦPer Lin. Ft.		13.67	13.83	14.00	14.17	14.33	14.50	14.67	14.83	15.00	15.17	15.33	15.50	15.67	15.83	16.00	16.17	16.33	16.50	16.67			ΦPer Lin Ft	
10#	#26	14.17	14.33	14.50	14.67	14.83	15.00	15.17	15.33	15.58	15.75	15.92	16.08	16.25	16.42	16.58	16.75	16.92	17.08	17.25			#26	10#
12#	#24	17.00	17.20	17.40	17.60	17.80	18.00	18.20	18.40	18.70	18.90	19.10	19.30	19.50	19.70	19.90	20.10	20.30	20.50	20.70			#24	12#
1.5#	#22	21.25	21.50	21.75	22.00	22.25	22.50	22.75	23.00	23.38	23.63	23.88	24.13	24.38	24.63	24.88	25.13	25.38	25.63	25.88			#22	15#
17#	#20	24.08	24.37	24.65	24.93	25.22	25.50	25.78	26.07	26.49	26.78	27.06	27.34	27.63	27.91	28.19	28.48	28.76	29.04	29.33			#20	17#
22#	#18	31.17	31.53	31.90	32.27	32.63	33.00	33.37	33.73	34.28	34.65	35.02	35.38	35.75	36.12	36.48	36.85	37.22	37.58	37.95			#18	22#
27#	#16	38.25	38.70	39.15	39.60	40.05	40.50	40.95	41.40	42.08	42.53	42.98	43.43	43.88	44.33	44.78	45.23	45.68	46.13	46.58			#16	27#
Wt.p.Φ	Gauge	WEIGHT OF GALVANIZED IRON RECTANGULAR DUCTS PER LINEAL FOOT																					Gauge	Wt.p.Φ

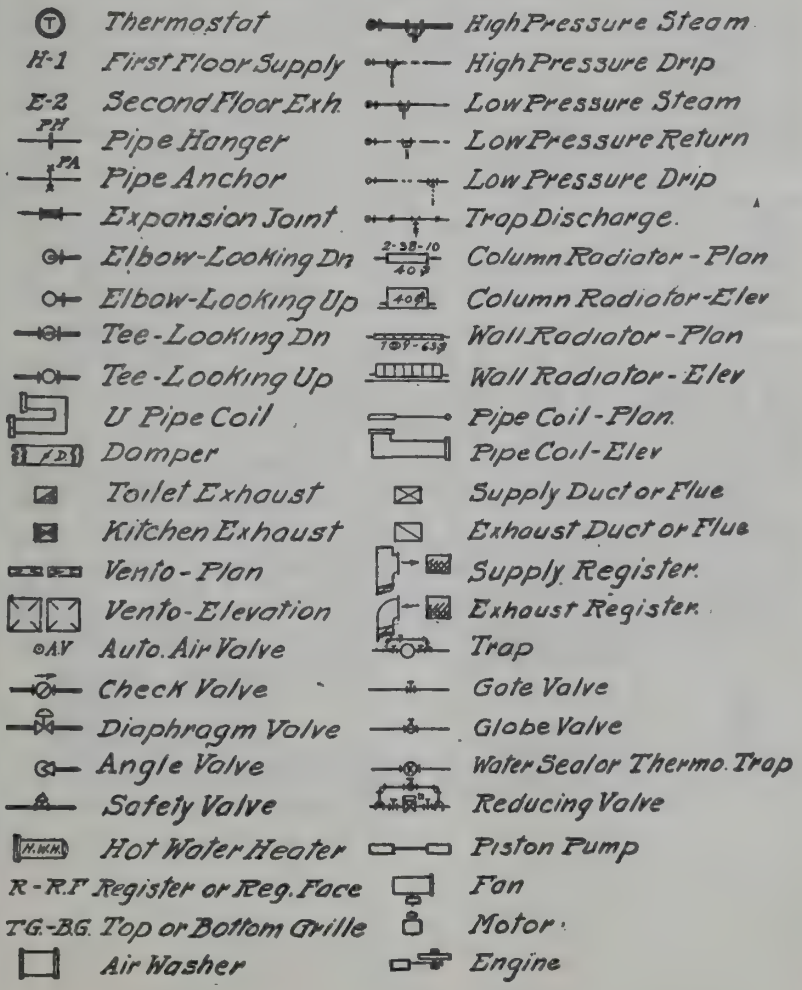
TABLES FOR VENTILATING DUCTS.

Superficial Area and Weight of Galvanized Sheet Iron Rectangular Ducts.

Wt p Φ	Gauge	WEIGHT OF GALVANIZED IRON RECTANGULAR DUCTS PER LINEAL FOOT																					Gauge	Wt p Φ
2.7#	#16		38.25	38.70	39.15	39.60	40.05	40.50	40.95	41.40	42.08	42.63	42.98	43.43	43.88	44.33	44.78	45.23	45.68	46.13	46.58	47.03	#16	2.7#
2.2#	#18		31.17	31.53	31.90	32.27	32.63	33.00	33.37	33.73	34.28	34.65	35.02	35.38	35.75	36.12	36.48	36.85	37.22	37.58	37.95	38.32	#18	2.2#
1.7#	#20		24.08	24.37	24.65	24.93	25.22	25.50	25.78	26.07	26.49	26.78	27.06	27.34	27.63	27.91	28.19	28.48	28.76	29.04	29.33	29.61	#20	1.7#
1.5#	#22		21.25	21.50	21.75	22.00	22.25	22.50	22.75	23.00	23.38	23.63	23.88	24.13	24.38	24.63	24.88	25.13	25.38	25.63	25.88	26.13	#22	1.5#
1.2#	#24		17.00	17.20	17.40	17.60	17.80	18.00	18.20	18.40	18.70	18.90	19.10	19.30	19.50	19.70	19.90	20.10	20.30	20.50	20.70	20.90	#24	1.2#
1.0#	#26		14.17	14.33	14.50	14.67	14.83	15.00	15.17	15.33	15.58	16.75	15.92	16.08	16.25	16.42	16.58	16.75	16.92	17.08	17.25	17.42	#26	1.0#
Φ Per Lin Ft			13.67	13.83	14.00	14.17	14.33	14.50	14.67	14.83	15.00	15.17	15.33	15.50	15.67	15.83	16.00	16.17	16.33	16.50	16.67	16.83	Φ Per Lin Ft	
CROSS SECTIONAL DIMENSIONS OF DUCTS IN INCHES	41		41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	41	CROSS SECTIONAL DIMENSIONS OF DUCTS IN INCHES
	42	60		41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	42	
	43	59	60		41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	43	
	44	58	59	60		41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	44	
	45	57	58	59	60		41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	45	
	46	56	57	58	59	60		41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	46	
	47	55	56	57	58	59	60		41	42	43	44	45	46	47	48	49	50	51	52	53	54	47	
	48	54	55	56	57	58	59	60		41	42	43	44	45	46	47	48	49	50	51	52	53	48	
	49	53	54	55	56	57	58	59	60		41	42	43	44	45	46	47	48	49	50	51	52	49	
	50	52	53	54	55	56	57	58	59	60		41	42	43	44	45	46	47	48	49	50	51	50	
	51	51	52	53	54	55	56	57	58	59	60		41	42	43	44	45	46	47	48	49	50	51	
	52	50	51	52	53	54	55	56	57	58	59	60		41	42	43	44	45	46	47	48	49	52	
	53	49	50	51	52	53	54	55	56	57	58	59	60		41	42	43	44	45	46	47	48	53	
	54	48	49	50	51	52	53	54	55	56	57	58	59	60		41	42	43	44	45	46	47	54	
	55	47	48	49	50	51	52	53	54	55	56	57	58	59	60		41	42	43	44	45	46	55	
	56	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60		41	42	43	44	45	56	
	57	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60		41	42	43	44	57	
	58	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60		41	42	43	58	
	59	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60		41	42	59	
	60	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60		41	60	
Φ Per Lin Ft		17.00	17.17	17.33	17.50	17.67	17.83	18.00	18.17	18.33	18.50	18.67	18.83	19.00	19.17	19.33	19.50	19.67	19.83	20.00			Φ Per Lin Ft	
1.0#	#26	17.58	17.75	17.92	18.17	18.33	18.50	18.67	18.83	19.00	19.17	19.33	19.50	19.67	19.83	20.00	20.17	20.33	20.50	20.75			#26	1.0#
1.2#	#24	21.10	21.30	21.50	21.80	22.00	22.20	22.40	22.60	22.80	23.00	23.20	23.40	23.60	23.80	24.00	24.20	24.40	24.60	24.90			#24	1.2#
1.5#	#22	26.38	26.63	26.88	27.25	27.50	27.75	28.00	28.25	28.50	28.75	29.00	29.25	29.50	29.75	30.00	30.25	30.50	30.75	31.13			#22	1.5#
1.7#	#20	29.87	30.18	30.46	30.88	31.17	31.45	31.73	32.02	32.30	32.58	32.87	33.15	33.43	33.72	34.00	34.28	34.57	34.85	35.28			#20	1.7#
2.2#	#18	38.68	39.05	39.42	39.77	40.33	40.70	41.07	41.43	41.80	42.17	42.53	42.90	43.27	43.63	44.00	44.37	44.73	45.10	45.65			#18	2.2#
2.7#	#16	47.48	47.93	48.38	49.05	49.50	49.95	50.40	50.85	51.30	51.75	52.20	52.65	53.10	53.56	54.00	54.45	54.90	55.35	56.03			#16	2.7#
Wt p Φ	Gauge	WEIGHT OF GALVANIZED IRON RECTANGULAR DUCTS PER LINEAL FOOT																					Gauge	Wt p Φ

STANDARD HEATING AND VENTILATING SYMBOLS

While there are many symbols in use in various parts of the country and even by different designers in the same sections, the symbols shown below are the ones most closely approximated by a majority of the largest and most responsible firms engaged in such work. It is hardly necessary to point out the desirability of universally using the same symbols throughout the country and it is believed that the following are clear, practical and easy to make and read.



COMPUTING RADIATION.

In computing the amount of radiation, the kind of radiator surface to be used, its method of installation whether direct, recessed, concealed or indirect, the work it must do and its position in the room—all bear upon the matter. Care must be taken to distinguish between *actual* radiator surface and *equivalent* direct radiator surface (E. D. R.). Actual radiator surface is the actual exposed radiating surface expressed in square feet but E. D. R. depends entirely on its efficiency. Equivalent direct radiation (E. D. R.) is most easily defined as being ¼ lb. of steam (or 250 B. T. U.) per hour, this being the approximate condensation of 1 sq. ft. of actual cast-iron radiator surface under ordinary operating conditions.

Thus, if an indirect radiator of 10 sq. ft. actual surface is giving off heat at the rate of 400 B. T. U. per square foot per hour (or has an *efficiency* of 400 B. T. U.) its total B. T. U. delivered will be 10 × 400 = 4000, but its E D. R. will be 4000/250, or 16 sq. ft. In figuring boiler capacity, pipe sizes, and all other calculations relating to the heat delivered, steam required or condensation to be handled, the E. D. R. should be used as a basis of calculation.

Having found the B. T. U. required to heat a given room by use of the factors and formulae previously given on Data Sheets Nos. 1-7 calculation of the required radiating surface is usually made by dividing the total B. T. U. to be supplied by 250, which is the assumed efficiency of all radiation per square foot. While it is true all radiation does not give this efficiency (for exact results of tests on different styles of radiators see Standard Data Sheet No. 13-A) it is much easier to use the 250 divisor and then to add a percentage than to use a multitude of different divisors.

The only variation from this should be for indirect heaters which, for gravity work, are usually considered as having an efficiency of 400 or 500 B. T. U., and for pipe coils, which are usually considered as having an efficiency of 300 B. T. U., unless on the ceiling where the undesirable position causes such a reduction of efficiency that 250 B. T. U. is again correct.

Radiators installed so that the air does not circulate freely around them suffer a loss of efficiency and must be increased as follows:

Cast-iron radiators on ceiling	10%
Recessed radiators	20%
Concealed	40%
Radiators near doors	100%

The increase of radiators near doors is to have extra surface to counteract drafts when the doors are opened and to care for the larger leakage loss encountered in such locations.

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EFFICIENCY OF RADIATING SURFACE.

The efficiency of radiating surface varies in different types of radiators although not to such an extent as to make any great difference in the amount of surface used. The co-efficients of efficiency are computed by multiplying the condensation (in pounds per sq. ft. per hour) by the latent heat of the steam at its pressure and dividing by the temperature difference between the room and the steam in the radiator. Otherwise the co-efficient may be said to be the number of B. T. U. transmitted per square foot of heating surface per hour per degree difference.

Tests made by Professor J. R. Allen at the University of Michigan show those co-efficients to be as follows and column 4 is computed from column 3 on the basis of 5 lbs. of steam pressure and 150 degrees temperature difference.

Type of Radiating Surface.	No. of Pounds Condensed per Sq. Ft. per hr.	Co-efficient of Transmission B. T. U. per deg.	Efficiency of Surface B. T. U. per Sq. Ft. Per hr.
CAST-IRON			
1-column	0.212	1.82	273
2-column	0.265	1.65	248
3-column	0.204	1.45	218
6-column	0.217	1.35	202
5 sq. ft. wall (vertical)	——	1.92	288
5 sq. ft. wall (horizontal)	——	2.11	317
7 sq. ft. wall (vertical)	——	1.70	255
7 sq. ft. wall (horizontal)	——	1.92	288
9 sq. ft. wall (vertical)	——	1.77	265
9 sq. ft. wall (horizontal)	——	1.98	297
Bare pipe coils			
1 Pipe high	0.410	2.80	420
4 Pipes high	0.425	2.48	372
PRESSED STEEL			
2-column	——	1.53	222

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2-column	——	1.53	222

EXAMPLE OF COMPUTING DIRECT RADIATION.

Assume a room with three windows and one door with a computed loss of 20,000 B. T. U. Then the direct radiator surface will be 20,000/250 = 80 sq. ft. for either cast-iron radiators or pipe coils on the ceiling.

80 + 10% = 88 sq. ft. for cast-iron ceiling radiators.
80 + 20% = 96 sq. ft. for cast-iron recessed radiators.
80 + 40% = 112 sq. ft. for cast-iron concealed radiators.

If ordinary exposed radiators are used they may be divided into four radiators of 20 sq. ft. each—which however, is rather too small for practical use. Probably three would be used, two of 27 sq. ft. and one—near the door—of 54 sq. ft.

For pipe coils along the walls near the floor the surface would be 20,000/300 = 67 sq. ft.

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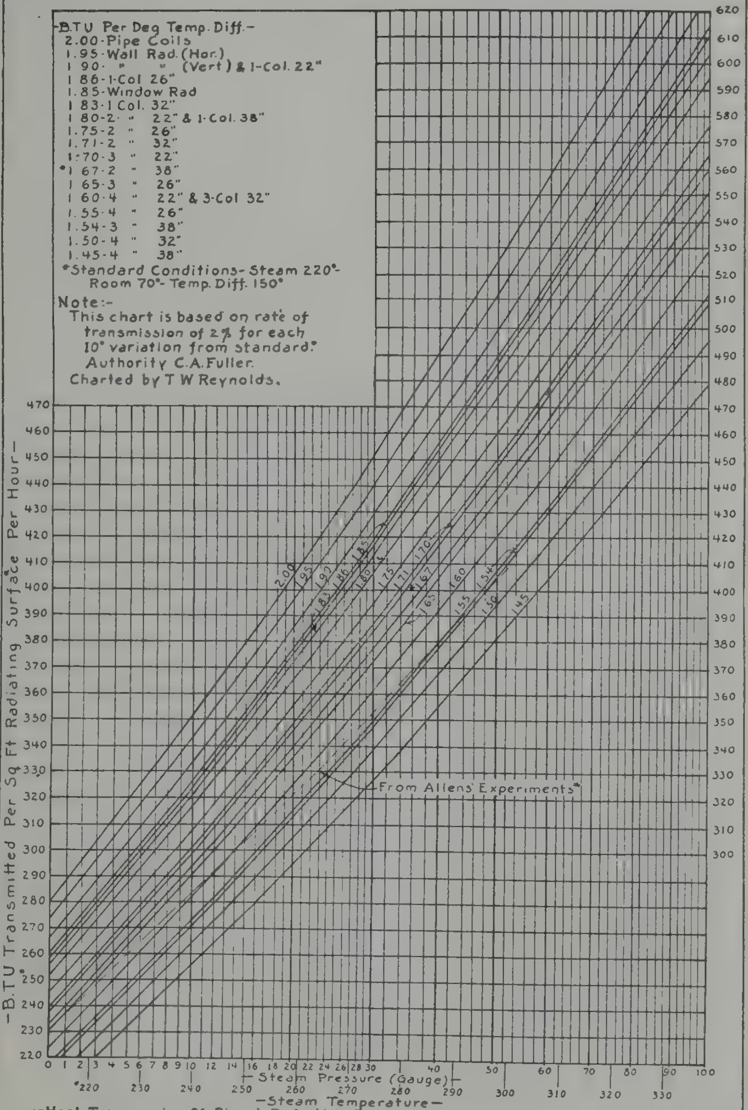
HEAT TRANSMISSION FROM DIRECT RADIATORS



—Heat Transmission Of Direct Radiation For Various Steam Pressures & Temp Differences—

EXAMPLE: Assume a room temperature of 60° F. and a steam temperature of 230° F., which gives a temperature difference of 170°. This is 20° more than the standard conditions of 150°, and allowing 2% for each 10° variation, the values must be increased 4%. Assuming a 2-col. radiator 32 in. high, the factor is 1.71.

$1.71 \times 0.04 = 0.068$.

$1.71 + 0.068 = 1.778$ B. T. U. per degree difference.

$1.778 \times 170 = 302$ B. T. U. transmitted per square foot per hour.

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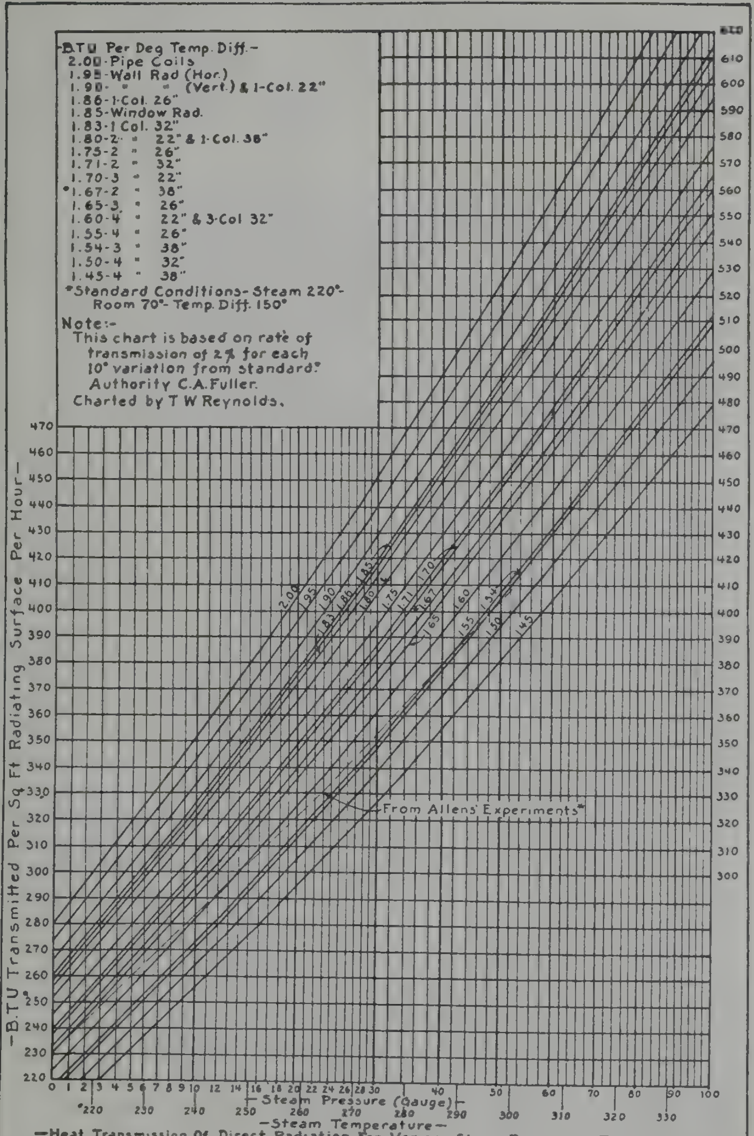

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1.71 + 0.068 = 1.778 B. T. U. per degree difference.

1.778 × 170 = 302 B. T. U. transmitted per square foot per hour.

RADIATION COMPUTING CHARTS.

Walls.

Based on 12-in. brick wall, furred and plastered. K factor = 0.26. Heat emission from radiators, 250 B. T. U. For temperatures other than 0° F. add 1.43% for each degree. For other building materials, multiply the values selected by a factor obtained by dividing the K factor for the material of which the building is constructed, by 0.26.

TABLE II

SQUARE FT. OF DIRECT CAST IRON STEAM RADIATION FOR HEAT LOSS THRU WALL AREA OF VARIOUS DIMENSIONS. ROOM TEMP. 70° FAHR. OUTSIDE TEMP. 0°

HEIGHT OF	RUNNING FEET OF EXPOSED WALL WITHOUT REGARD TO WINDOW OPENINGS																		
CEILING	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
8	5.28	6.16	7.04	7.92	8.80	9.68	10.56	11.44	12.32	13.20	14.08	14.96	15.84	16.72	17.60	18.48	19.36	20.24	21.12
8½	5.61	6.60	7.48	8.36	9.35	10.34	11.22	12.10	13.09	13.97	14.96	15.95	16.83	17.82	18.70	19.58	20.57	21.45	22.44
9	5.94	6.93	7.92	8.91	9.90	10.89	11.88	12.87	13.86	14.85	15.84	16.83	17.82	18.81	19.80	20.79	21.78	22.77	23.76
9½	6.27	7.26	8.36	9.46	10.45	11.55	12.54	13.53	14.63	15.62	16.72	17.71	18.81	19.91	20.90	22.00	22.99	23.98	25.08
10	6.60	7.70	8.80	9.90	11.00	12.10	13.20	14.30	15.40	16.50	17.60	18.70	19.80	20.90	22.00	23.10	24.20	25.30	26.40
10½	6.93	8.03	9.24	10.34	11.55	12.65	13.86	14.96	16.17	17.27	18.48	19.58	20.79	21.89	23.10	24.20	25.41	26.62	27.72
11	7.26	8.47	9.68	10.89	12.10	13.31	14.52	15.73	16.94	18.15	19.36	20.57	21.78	22.99	24.20	25.41	26.62	27.83	29.04
11½	7.59	8.80	10.12	11.44	12.65	13.86	15.18	16.39	17.71	18.92	20.24	21.45	22.77	23.98	25.30	26.51	27.83	29.15	30.36
12	7.92	9.24	10.56	11.88	13.20	14.52	15.84	17.16	18.48	19.80	21.12	22.44	23.76	25.08	26.40	27.72	29.04	30.36	31.68
12½	8.25	9.57	11.00	12.32	13.75	15.07	16.50	17.82	19.25	20.57	22.00	23.32	24.75	26.18	27.50	28.82	30.25	31.57	33.00
13	8.58	10.01	11.44	12.87	14.30	15.73	17.16	18.59	19.91	21.45	22.88	24.31	25.74	27.17	28.60	30.03	31.46	32.89	34.32
14	9.24	10.78	12.32	13.56	15.40	16.94	18.48	20.02	21.56	23.10	24.64	26.18	27.72	29.26	30.80	32.34	33.88	35.42	36.96
CEILING HEIGHT	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43
8	22.00	22.88	23.76	24.64	25.52	26.40	27.28	28.16	29.04	29.92	30.80	31.68	32.56	33.44	34.32	35.20	36.08	36.96	37.84
8½	23.32	24.31	25.30	26.18	27.06	28.05	28.93	29.92	30.80	31.79	32.78	33.66	34.65	35.53	36.52	37.40	38.39	39.27	40.26
9	24.75	25.74	26.73	27.72	28.71	29.70	30.69	31.68	32.67	33.66	34.65	35.64	36.63	37.62	38.61	39.60	40.59	41.58	42.57
9½	26.07	27.17	28.16	29.26	30.25	31.35	32.34	33.44	34.43	35.53	36.52	37.62	38.61	39.71	40.70	41.80	42.79	43.89	44.88
10	27.50	28.60	29.70	30.80	31.90	33.00	34.10	35.20	36.30	37.40	38.50	39.60	40.70	41.80	42.92	44.00	45.10	46.20	47.30
10½	28.82	30.03	31.13	32.34	33.55	34.65	35.75	36.96	38.06	39.27	40.37	41.58	42.68	43.89	44.99	46.20	47.30	48.51	49.61
11	30.25	31.46	32.67	33.88	35.09	36.30	37.51	38.72	39.93	41.14	42.35	43.56	44.77	45.98	47.19	48.40	49.61	50.82	52.03
11½	31.57	32.89	34.10	35.42	36.63	37.95	39.16	40.48	41.69	43.01	44.33	45.54	46.86	48.07	49.39	50.60	51.81	53.13	54.34
12	33.00	34.32	35.64	36.96	38.28	39.60	40.92	42.24	43.56	44.88	46.20	47.52	48.84	50.16	51.48	52.80	54.12	55.44	56.76
12½	34.32	35.75	37.07	38.50	39.82	41.25	42.57	44.00	45.32	46.75	48.07	49.50	50.82	52.25	53.57	55.00	56.32	57.75	59.07
13	35.75	37.18	38.61	40.04	41.47	42.90	44.33	45.76	47.19	48.62	50.05	51.48	52.91	54.34	55.77	57.20	58.63	60.06	61.49
14	38.50	40.04	41.58	43.12	44.66	46.20	47.74	49.28	50.82	52.36	53.90	55.44	56.98	58.52	60.06	61.60	63.14	64.68	66.22

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RADIATION COMPUTING—WALL HEAT LOSS CHART. NO. 13-E.

RADIATION COMPUTING CHARTS.

Walls.

Based on 12-in. brick wall, furred and plastered. K factor = 0.26. Heat emission from radiators, 250 B. T. U. For temperatures other than 0° F. add 1.43% for each degree. For other building materials, multiply the values selected by a factor obtained by dividing the K factor for the material of which the building is constructed, by 0.26.

TABLE II

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HEIGHT OF	RUNNING FEET OF EXPOSED WALL WITHOUT REGARD TO WINDOW OPENINGS																		
CEILING	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
8	5.28	6.16	7.04	7.92	8.80	9.68	10.56	11.44	12.32	13.20	14.08	14.96	15.84	16.72	17.60	18.48	19.36	20.24	21.12
8½	5.61	6.60	7.48	8.36	9.35	10.34	11.22	12.10	13.09	13.97	14.96	15.95	16.83	17.82	18.70	19.58	20.57	21.45	22.44
9	5.94	6.93	7.92	8.91	9.90	10.89	11.88	12.87	13.86	14.85	15.84	16.83	17.82	18.81	19.80	20.79	21.78	22.77	23.76
9½	6.27	7.26	8.36	9.46	10.45	11.55	12.54	13.53	14.63	15.62	16.72	17.71	18.81	19.91	20.90	22.00	22.99	23.98	25.08
10	6.60	7.70	8.80	9.90	11.00	12.10	13.20	14.30	15.40	16.50	17.60	18.70	19.80	20.90	22.00	23.10	24.20	25.30	26.40
10½	6.93	8.03	9.24	10.34	11.55	12.65	13.86	14.96	16.17	17.27	18.48	19.58	20.79	21.89	23.10	24.20	25.41	26.62	27.72
11	7.26	8.47	9.68	10.89	12.10	13.31	14.52	15.73	16.94	18.15	19.36	20.57	21.78	22.99	24.20	25.41	26.62	27.83	29.04
11½	7.59	8.80	10.12	11.44	12.65	13.86	15.18	16.39	17.71	18.92	20.24	21.45	22.77	23.98	25.30	26.51	27.83	29.15	30.36
12	7.92	9.24	10.56	11.88	13.20	14.52	15.84	17.16	18.48	19.80	21.12	22.44	23.76	25.08	26.40	27.72	29.04	30.36	31.68
12½	8.25	9.57	11.00	12.32	13.75	15.07	16.50	17.82	19.25	20.57	22.00	23.32	24.75	26.18	27.50	28.82	30.25	31.57	33.00
13	8.58	10.01	11.44	12.87	14.30	15.73	17.16	18.59	19.91	21.45	22.88	24.31	25.74	27.17	28.60	30.03	31.46	32.89	34.32
14	9.24	10.78	12.32	13.56	15.40	16.94	18.48	20.02	21.56	23.10	24.64	26.18	27.72	29.26	30.80	32.34	33.88	35.42	36.96
CEILING HEIGHT	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43
8	22.00	22.88	23.76	24.64	25.52	26.40	27.28	28.16	29.04	29.92	30.80	31.68	32.56	33.44	34.32	35.20	36.08	36.96	37.84
8½	23.32	24.31	25.30	26.18	27.06	28.05	28.93	29.92	30.80	31.79	32.78	33.66	34.65	35.53	36.52	37.40	38.39	39.27	40.26
9	24.75	25.74	26.73	27.72	28.71	29.70	30.69	31.68	32.67	33.66	34.65	35.64	36.63	37.62	38.61	39.60	40.59	41.58	42.57
9½	26.07	27.17	28.16	29.26	30.25	31.35	32.34	33.44	34.43	35.53	36.52	37.62	38.61	39.71	40.70	41.80	42.79	43.89	44.88
10	27.50	28.60	29.70	30.80	31.90	33.00	34.10	35.20	36.30	37.40	38.50	39.60	40.70	41.80	42.92	44.00	45.10	46.20	47.30
10½	28.82	30.03	31.13	32.34	33.55	34.65	35.75	36.96	38.06	39.27	40.37	41.58	42.68	43.89	44.99	46.20	47.30	48.51	49.61
11	30.25	31.46	32.67	33.88	35.09	36.30	37.51	38.72	39.93	41.14	42.35	43.56	44.77	45.98	47.19	48.40	49.61	50.82	52.03
11½	31.57	32.89	34.10	35.42	36.63	37.95	39.16	40.48	41.69	43.01	44.33	45.54	46.86	48.07	49.39	50.60	51.81	53.13	54.34
12	33.00	34.32	35.64	36.96	38.28	39.60	40.92	42.24	43.56	44.88	46.20	47.52	48.84	50.16	51.48	52.80	54.12	55.44	56.76
12½	34.32	35.75	37.07	38.50	39.82	41.25	42.57	44.00	45.32	46.75	48.07	49.50	50.82	52.25	53.57	55.00	56.32	57.75	59.07
13	35.75	37.18	38.61	40.04	41.47	42.90	44.33	45.76	47.19	48.62	50.05	51.48	52.91	54.34	55.77	57.20	58.63	60.06	61.49
14	38.50	40.04	41.58	43.12	44.66	46.20	47.74	49.28	50.82	52.36	53.90	55.44	56.98	58.52	60.06	61.60	63.14	64.68	66.22

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RADIATION COMPUTING CHARTS.

Windows.

Based on single thickness of glass. K factor = 1. Heat emission from radiators, 250 B. T. U. For temperatures other than 0° F. add 1.43% for each degree.

TABLE I

SQUARE FT. OF DIRECT CAST IRON STEAM RADIATION FOR HEAT LOSS THROUGH TWO PANE WINDOWS, INCLUDING SASH. ROOM TEMP. 70° FAHR. OUTSIDE TEMP. 0° F.

WIDTH GLASS	WIDTH OF OPENING	HEIGHT GLASS	18"	20"	22"	24"	26"	28"	30"	32"	34"	36"	38"	40"	42"	44"	46"	48"	50"	52"	54"
INS.	FT. IN.	HEIGHT OPENING	3'-6"	3'-10"	4'-2"	4'-6"	4'-10"	5'-2"	5'-6"	5-10"	6'-2"	6'-6"	6'-10"	7'-2"	7'-6"	7'-10"	8'-2"	8-6"	8'-10"	9'-2"	9'-6"
16	1-8	STANDARD SIZES OF TWO-LIGHT WINDOWS	2.69	2.94	3.22	3.45	3.68	3.96	4.23	4.46	4.74	4.97	5.24	5.47	5.75	5.98	6.26	6.53	6.76	6.99	7.27
18	1-10		2.94	3.22	3.49	3.77	4.09	4.37	4.65	4.92	5.20	5.47	5.75	6.03	6.30	6.58	6.90	7.18	7.45	7.73	8.00
20	2-0		3.22	3.54	3.82	4.14	4.46	4.74	5.06	5.38	5.66	5.98	6.26	6.58	6.90	7.18	7.50	7.82	8.14	8.42	3.74
22	2-2		3.40	3.82	4.14	4.46	4.83	5.15	5.47	5.80	6.16	6.44	6.76	7.13	7.45	7.82	8.14	8.46	8.83	9.11	9.48
24	2-4		3.77	4.09	4.46	4.83	5.20	5.52	5.89	6.26	6.62	6.95	7.31	7.68	8.00	8.37	8.74	9.11	9.48	9.84	10.21
26	2-6		3.99	4.42	4.78	5.15	5.52	5.89	6.30	6.72	7.08	7.45	7.87	8.23	8.60	8.97	9.38	9.75	10.12	10.58	10.95
28	2-8		4.28	4.69	5.11	5.52	5.93	6.35	6.76	7.13	7.54	7.96	8.37	8.79	9.20	9.57	10.03	10.39	10.81	11.22	11.64
30	2-10		4.60	4.97	5.43	5.89	6.30	6.72	7.18	7.59	8.05	8.46	8.88	9.34	9.75	10.21	10.67	11.04	11.50	11.96	12.42
32	3-0		4.83	5.29	5.75	6.21	6.67	7.13	7.59	8.05	8.51	8.97	9.43	9.89	10.35	10.81	11.27	11.73	12.19	12.65	13.11
34	3-2		5.06	5.57	6.07	6.58	7.04	7.54	8.00	8.51	8.97	9.48	9.94	10.40	10.90	11.41	11.87	12.42	12.88	13.34	13.80
36	3-4		5.38	5.89	6.39	6.90	7.41	7.91	8.42	8.97	9.43	9.94	10.49	10.95	11.50	12.01	12.51	13.02	13.52	14.03	14.58
38	3-6		5.61	6.16	6.72	7.27	7.77	8.28	8.83	9.38	9.94	10.44	11.04	11.50	12.05	12.60	13.16	13.71	14.26	14.77	15.27
40	3-8		5.89	6.44	7.04	7.59	8.14	8.69	9.25	9.84	10.39	10.95	11.55	12.05	12.60	13.20	13.80	14.35	14.90	15.46	16.05
42	3-10		6.16	6.76	7.36	7.96	8.51	9.11	9.66	10.30	10.86	11.45	12.05	12.60	13.16	13.80	14.40	14.99	15.55	16.10	16.74
44	4-0		6.44	7.04	7.68	8.28	8.88	9.52	10.12	10.76	11.32	11.96	12.56	13.16	13.80	14.40	14.99	15.64	16.24	16.79	17.48
46	4-2		6.72	7.36	8.00	8.65	9.25	9.89	10.58	11.22	11.78	12.47	13.06	13.71	14.35	14.99	15.64	16.33	16.93	17.57	18.22
48	4-4		6.99	7.64	8.28	8.97	9.61	10.30	10.95	11.64	12.28	12.93	13.57	14.26	14.90	15.64	16.28	16.93	17.62	18.22	18.86
50	4-6		7.22	7.91	8.60	9.34	10.03	10.67	11.41	12.05	12.74	13.43	14.12	14.81	15.50	16.19	16.88	17.57	18.26	18.95	19.59
52	4-8		7.49	8.23	8.92	9.66	10.35	11.04	11.78	12.51	13.20	13.94	14.63	15.36	16.10	16.79	17.48	18.22	18.95	19.64	20.33
54	4-10		7.77	8.51	9.25	10.03	10.76	11.50	12.24	12.97	13.71	14.44	15.13	15.92	16.65	17.39	18.17	18.86	19.64	20.38	21.16
56	5-0		8.05	8.88	9.57	10.35	11.13	11.89	12.65	13.34	14.17	14.95	15.64	16.47	17.25	18.31	18.77	19.55	20.33	21.16	21.85

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RADIATION COMPUTING CHARTS.

Windows.

Based on single thickness of glass. K factor = 1. Heat emission from radiators, 250 B. T. U. For temperatures other than 0° F. add 1.43% for each degree.

TABLE I

SQUARE FT. OF DIRECT CAST IRON STEAM RADIATION FOR HEAT LOSS THROUGH TWO PANE WINDOWS, INCLUDING SASH. ROOM TEMP. 70° FAHR. OUTSIDE TEMP. 0° F.

Width Glass Ins.	Width of Opening Ft. In.	Height Glass	18"	20"	22"	24"	26"	28"	30"	32"	34"	36"	38"	40"	42"	44"	46"	48"	50"	52"	54"
		Height Opening	3'-6"	3'-10"	4'-2"	4'-6"	4'-10"	5'-2"	5'-6"	5-10"	6'-2"	6'-6"	6'-10"	7'-2"	7'-6"	7'-10"	8'-2"	8-6"	8'-10"	9'-2"	9'-6"
16	1-8	STANDARD SIZES OF TWO-LIGHT WINDOWS	2.69	2.94	3.22	3.45	3.68	3.96	4.23	4.46	4.74	4.97	5.24	5.47	5.75	5.98	6.26	6.53	6.76	6.99	7.27
18	1-10		2.94	3.22	3.49	3.77	4.09	4.37	4.65	4.92	5.20	5.47	5.75	6.03	6.30	6.58	6.90	7.18	7.45	7.73	8.00
20	2-0		3.22	3.54	3.82	4.14	4.46	4.74	5.06	5.38	5.66	5.98	6.26	6.58	6.90	7.18	7.50	7.82	8.14	8.42	8.74
22	2-2		3.40	3.82	4.14	4.46	4.83	5.15	5.47	5.80	6.16	6.44	6.76	7.13	7.45	7.82	8.14	8.46	8.83	9.11	9.48
24	2-4		3.77	4.09	4.46	4.83	5.20	5.52	5.89	6.26	6.62	6.95	7.31	7.68	8.00	8.37	8.74	9.11	9.48	9.84	10.21
26	2-6		3.99	4.42	4.78	5.15	5.52	5.89	6.30	6.72	7.08	7.45	7.87	8.23	8.60	8.97	9.38	9.75	10.12	10.58	10.95
28	2-8		4.28	4.69	5.11	5.52	5.93	6.35	6.76	7.13	7.54	7.96	8.37	8.79	9.20	9.57	10.03	10.39	10.81	11.22	11.64
30	2-10		4.60	4.97	5.43	5.89	6.30	6.72	7.18	7.59	8.05	8.46	8.88	9.34	9.75	10.21	10.67	11.04	11.50	11.96	12.42
32	3-0		4.83	5.29	5.75	6.21	6.67	7.13	7.59	8.05	8.51	8.97	9.43	9.89	10.35	10.81	11.27	11.73	12.19	12.65	13.11
34	3-2		5.06	5.57	6.07	6.58	7.04	7.54	8.00	8.51	8.97	9.48	9.94	10.40	10.90	11.41	11.87	12.42	12.88	13.34	13.80
36	3-4		5.38	5.89	6.39	6.90	7.41	7.91	8.42	8.97	9.43	9.94	10.49	10.95	11.50	12.01	12.51	13.02	13.52	14.03	14.58
38	3-6		5.61	6.16	6.72	7.27	7.77	8.28	8.83	9.38	9.94	10.44	11.04	11.50	12.05	12.60	13.16	13.71	14.26	14.77	15.27
40	3-8		5.89	6.44	7.04	7.59	8.14	8.69	9.25	9.84	10.39	10.95	11.55	12.05	12.60	13.20	13.80	14.35	14.90	15.46	16.05
42	3-10		6.16	6.76	7.36	7.96	8.51	9.11	9.66	10.30	10.86	11.45	12.05	12.60	13.16	13.80	14.40	14.99	15.55	16.10	16.74
44	4-0		6.44	7.04	7.68	8.28	8.88	9.52	10.12	10.76	11.32	11.96	12.56	13.16	13.80	14.40	14.99	15.64	16.24	16.79	17.48
46	4-2		6.72	7.36	8.00	8.65	9.25	9.89	10.58	11.22	11.78	12.47	13.06	13.71	14.35	14.99	15.64	16.33	16.93	17.57	18.22
48	4-4		6.99	7.64	8.28	8.97	9.61	10.30	10.95	11.64	12.28	12.93	13.57	14.26	14.90	15.64	16.28	16.93	17.62	18.22	18.86
50	4-6		7.22	7.91	8.60	9.34	10.03	10.67	11.41	12.05	12.74	13.43	14.12	14.81	15.50	16.19	16.88	17.57	18.26	18.95	19.59
52	4-8		7.49	8.23	8.92	9.66	10.35	11.04	11.78	12.51	13.20	13.94	14.63	15.36	16.10	16.79	17.48	18.22	18.95	19.64	20.33
54	4-10		7.77	8.51	9.25	10.03	10.76	11.50	12.24	12.97	13.71	14.44	15.13	15.92	16.65	17.39	18.17	18.86	19.64	20.38	21.16
56	5-0		8.05	8.88	9.57	10.35	11.13	11.89	12.65	13.34	14.17	14.95	15.64	16.47	17.25	18.31	18.77	19.55	20.33	21.16	21.85

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RADIATION COMPUTING CHARTS.

The Croney Tables.

Note: The figures represented in the following sheets are compiled from data obtained from Nelson S. Thompson's "Mechanical Equipment of Federal Buildings," published by the Heating and Ventilating Magazine Company. All calculations made with the slide rule. Fractions above 0.5 added and all below 0.5 deducted. Wind leakage has been taken care of for ordinary cases and is based entirely on the window perimeter.

Special Leakage Allowance.

To find the allowance for leakage in any room in cubic feet of air per hour, raised from 10° to 70° F., multiply the total estimated radiation by the following factors:

BRICK WALL CONSTRUCTION.

Cubic feet per hour = 61 × square feet direct steam radiation.
Cubic feet per hour = 37 × square feet direct water radiation.

Radiation for Additional Leakage.

If it is desired to provide for a greater allowance than above use the following:

$$\text{Additional steam radiation} = \frac{\text{desired volume per hour}}{234}$$

$$\text{Additional water radiation} = \frac{\text{desired volume per hour}}{140}$$

STONE WALL CONSTRUCTION.

Cubic feet per hour = 47 × square feet direct steam radiation.
Cubic feet per hour = 28 × square feet direct water radiation.
Steam radiation figured at 250 B. T. U.
Water radiation figured at 150 B. T. U.

For Vapor Heating:

Take total direct radiation for steam and work out as follows:

$$\frac{\text{Total radiation} \times 250}{220} = \text{radiation for vapor.}$$

Add 2% per foot for ceilings over 12 ft. high and 20% to all ceiling radiators.

RADIATION COMPUTING CHARTS.

The Croney Tables.

Note: The figures represented in the following sheets are compiled from data obtained from Nelson S. Thompson's "Mechanical Equipment of Federal Buildings," published by the Heating and Ventilating Magazine Company. All calculations made with the slide rule. Fractions above 0.5 added and all below 0.5 deducted. Wind leakage has been taken care of for ordinary cases and is based entirely on the window perimeter.

Special Leakage Allowance.

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Water radiation figured at 150 B. T. U.

For Vapor Heating:

Take total direct radiation for steam and work out as follows:

$$\frac{\text{Total radiation} \times 250}{220} = \text{radiation for vapor.}$$

Add 2% per foot for ceilings over 12 ft. high and 20% to all ceiling radiators.

RADIATION COMPUTING CHARTS.

The Croney Tables.

EXAMPLE.

To find the amount of steam radiation in a room 12 ft. x 14 ft. x 10-ft. ceiling, 12-in. brick walls, air space, lath and plaster:

12-ft. side, facing the north.
14-ft. side, facing the east.
Each wall having one window, 4 ft. x 5 ft.
Ceiling exposed to an attic room having no heat.
Floor over an ordinary cellar.

North wall 12 ft. x 10 ft. = 120 sq. ft. gross wall.
North glass 4 ft. x 5 ft. = 20 sq. ft. glass.
100 sq. ft. net wall.

East wall 14 ft. x 10 ft. = 140 sq. ft. gross wall.
East glass 4 ft. x 5 ft. = 20 sq. ft. glass.
120 sq. ft. net wall.

Ceiling 12 ft. x 14 ft. = 168 sq. ft.
Floor 12 ft. x 14 ft. = 168 sq. ft.

RESULT.

North wall 100 sq. ft. = 12 sq. ft. direct radiation.
East wall 120 sq. ft. = 12 sq. ft. direct radiation.
North glass 20 sq. ft. = 10 sq. ft. direct radiation.
East glass 20 sq. ft. = 9 sq. ft. direct radiation.

Total 43 sq. ft. direct radiation.

On Data Sheet No. 13-I. Column I, marked "Net Exposed Wall," locate 100. Opposite 100 and under "N, or N. W." read 12, which equals the amount of direct radiation for 100 sq. ft. of net wall.

On the same table, Column No. 1, marked "Net Exposed Wall," locate 120. Opposite 120 and under "E. or S. W." read 12, which equals the amount of direct radiation for 120 sq. ft. of net wall.

On Data Sheet No. 13-R, Column 1, marked "Net Exposed Glass," locate 20. Opposite 20 and under "N. or N. W." read 10, which equals the amount of direct radiation for 20 sq. ft. of glass. On the same table and under Column "E. or S. W." opposite 20 read 9, which equals the amount of direct radiation for 20 sq. ft. of glass.

Ceiling table (Data Sheet No. 13-II) equals top floor ceiling of residences, etc., and under "Area in Square Feet" we locate the nearest to 168, or 160. Opposite the 160, in Column A, we find 13 sq. ft., which equals the amount of direct radiation for 160 sq. ft. of ceiling.

In Floor Table (Data Sheet No. 13-LL) using the same process as worked out in Ceiling Table (Data Sheet No. 13-II) we get 2 sq. ft. of radiation.

Summary for direct radiation 43 plus 13 plus 22 = 58 sq. ft. of radiation.

Suppose, for some reason, the designer wants to know what air change per hour 58 sq. ft. of radiation will take care of. The first thing to do is to find the contents of the room, 12 ft. x 14 ft. x 10 ft. = 1680 cu. ft.

Then on Data Sheet No. 13-G, under "Brick Wall Construction," we find that the cubic feet of air per hour taken care of by the amount of radiation installed would be 58 times the factor 61, or 3538 cu. ft. Then, since the contents of the room are 1680 cu. ft., we would have 3538 divided by 1680, or approximately 2.1 air changes per hour.

Suppose four air changes per hour are required. Multiply 1680 cu. ft. by 4, which equals 6720 cu. ft. air per hour for four air changes.

The amount of air per hour taken care of by 58 sq. ft. of radiation, as above, equals 3598 subtracted from 6720 or 3187 cu. ft. air per hour to be compensated for. Dividing 3121 by 234 (Data Sheet No. 13-G) we get 13 plus, or 14 sq. ft. additional radiation to add to the 59 sq. ft., or a total of 73 sq. ft.

Suppose indirect radiation was required for the room. The entire result can be obtained from Data Sheet No. 13-CC.* First, under column "Direct Radiation," and the nearest quantity to 39 sq. ft. under "Brick Wall." (In this case take 64 sq. ft., owing to indirect radiation.) Then follow across. The next column will show 1.361 lbs. per hour. Then next column shows 9 sections, of 40-in. Vento, spaced on 4-in. centers, one section deep. The next column shows 96.75 sq. ft., which is the amount of indirect radiation installed in the indirect stack.

Second, under "Flue Area," will be found 270 sq. in. of heat flue for the first floor. The next column shows 162 sq. ft. of heat flue for the second floor and 177 sq. in. of heat flue for the mezzanine floor.

Third, for either of the above, registers should be not less than 450 sq. in. gross, as found in the last column, "Register Areas."

*Will appear in later issue.

RADIATION COMPUTING CHARTS.

The Croney Tables.

EXAMPLE.

To find the amount of steam radiation in a room 12 ft. x 14 ft. x 10-ft. ceiling, 12-in. brick walls, air space, lath and plaster:

12-ft. side, facing the north.
14-ft. side, facing the east.
Each wall having one window, 4 ft. x 5 ft.
·Ceiling exposed to an attic room having no heat.
Floor over an ordinary cellar.

North wall 12 ft. x 10 ft. = 120 sq. ft. gross wall.
North glass 4 ft. x 5 ft. = 20 sq. ft. glass.
100 sq. ft. net wall.
East wall 14 ft. x 10 ft. = 140 sq. ft. gross wall.
East glass 4 ft. x 5 ft. = 20 sq. ft. glass.
120 sq. ft. net wall.
Ceiling 12 ft. x 14 ft. = 168 sq. ft.
Floor 12 ft. x 14 ft. = 168 sq. ft.

RESULT.

North wall 100 sq. ft. = 12 sq. ft. direct radiation.
East wall 120 sq. ft. = 12 sq. ft. direct radiation.
North glass 20 sq. ft. = 10 sq. ft. direct radiation.
East glass 20 sq. ft. = 9 sq. ft. direct radiation.
Total 43 sq. ft. direct radiation.

On Data Sheet No. 13-I. Column I, marked "Net Exposed Wall," locate 100. Opposite 100 and under "N, or N. W." read 12, which equals the amount of direct radiation for 100 sq. ft. of net wall.

On the same table, Column No. 1, marked "Net Exposed Wall," locate 120. Opposite 120 and under "E. or S. W." read 12, which equals the amount of direct radiation for 120 sq. ft. of net wall.

On Data Sheet No. 13-R, Column 1, marked "Net Exposed Glass," locate 20. Opposite 20 and under "N. or N. W." read 10, which equals the amount of direct radiation for 20 sq. ft. of glass. On the same table and under Column "E. or S. W." opposite 20 read 9, which equals the amount of direct radiation for 20 sq. ft. of glass.

Ceiling table (Data Sheet No. 13-II) equals top floor ceiling of residences, etc., and under "Area in Square Feet" we locate the nearest to 168, or 160. Opposite the 160, in Column A, we find 13 sq. ft., which equals the amount of direct radiation for 160 sq. ft. of ceiling.

In Floor Table (Data Sheet No. 13-LL) using the same process as worked out in Ceiling Table (Data Sheet No. 13-II) we get 2 sq. ft. of radiation.

Summary for direct radiation 43 plus 13 plus 22 = 58 sq. ft. of radiation.

Suppose, for some reason, the designer wants to know what air change per hour 58 sq. ft. of radiation will take care of. The first thing to do is to find the contents of the room, 12 ft. x 14 ft. x 10 ft. = 1680 cu. ft.

Then on Data Sheet No. 13-G, under "Brick Wall Construction," we find that the cubic feet of air per hour taken care of by the amount of radiation installed would be 58 times the factor 61, or 3538 cu. ft. Then, since the contents of the room are 1680 cu. ft., we would have 3538 divided by 1680, or approximately 2.1 air changes per hour.

Suppose four air changes per hour are required. Multiply 1680 cu. ft. by 4, which equals 6720 cu. ft. air per hour for four air changes.

The amount of air per hour taken care of by 58 sq. ft. of radiation, as above, equals 3598 subtracted from 6720 or 3187 cu. ft. air per hour to be compensated for. Dividing 3121 by 234 (Data Sheet No. 13-G) we get 13 plus, or 14 sq. ft. additional radiation to add to the 59 sq. ft., or a total of 73 sq. ft.

Suppose indirect radiation was required for the room. The entire result can be obtained from Data Sheet No. 13-CC.* First, under column "Direct Radiation," and the nearest quantity to 39 sq. ft. under "Brick Wall." (In this case take 64 sq. ft., owing to indirect radiation.) Then follow across. The next column will show 1.361 lbs. per hour. Then next column shows 9 sections, of 40-in. Vento, spaced on 4-in. centers, one section deep. The next column shows 96.75 sq. ft., which is the amount of indirect radiation installed in the indirect stack.

Second, under "Flue Area," will be found 270 sq. in. of heat flue for the first floor. The next column shows 162 sq. ft. of heat flue for the second floor and 177 sq. in. of heat flue for the mezzanine floor.

Third, for either of the above, registers should be not less than 450 sq. in. gross, as found in the last column, "Register Areas."

*Will appear in later issue.

RADIATION COMPUTING

Heating-Steam-

12" Brick Wall Lath, furring and plaster on inside.

Net Exp. Wall	Direct Radiation				Net Exp. Wall	Direct Radiation			
	S. or S.E.	N. or N.W.	W. or N.E.	E. or S.W.		S. or S.E.	N. or N.W.	W. or N.E.	E. or S.W.
20	2	2	2	2	900	86	108	99	90
40	4	5	4	4	920	87	111	101	92
60	6	7	7	6	940	89	113	103	94
80	8	10	9	8	960	91	115	105	96
100	10	12	11	10	980	93	117	108	98
120	11	14	13	12	1000	95	120	110	100
140	13	17	15	14	1020	97	123	112	102
160	15	19	18	16	1040	99	125	114	104
180	17	22	20	18	1060	101	127	116	106
200	19	24	22	20	1080	103	129	119	108
220	21	26	24	22	1000	105	132	121	110
240	23	29	26	24	1120	106	135	123	112
260	25	31	29	26	1140	108	137	125	114
280	27	34	31	28	1160	110	139	127	116
300	29	36	33	30	1180	112	141	131	118
320	30	38	35	32	1200	114	144	132	120
340	32	41	37	34	1220	116	147	134	122
360	34	43	40	36	1240	118	149	136	124
380	36	46	42	38	1260	120	151	138	126
400	38	48	44	40	1280	122	152	140	128
420	40	50	46	42	1300	124	156	143	130
440	42	53	48	44	1320	126	159	146	132
460	44	55	51	46	1340	127	161	147	134
480	46	58	53	48	1360	129	163	149	136
500	48	60	55	50	1380	131	165	151	138
520	49	62	57	52	1400	133	168	154	140
540	51	65	59	54	1420	135	171	156	142
560	53	67	62	56	1440	137	173	158	144
580	55	70	64	58	1460	139	175	160	146
600	57	72	66	60	1480	141	177	162	148
620	60	74	68	62	1500	143	180	164	150
640	61	77	70	64	1520	144	183	167	152
660	63	79	72	66	1540	146	185	169	154
680	65	81	75	68	1560	148	187	171	156
700	67	84	77	70	1580	150	189	173	158
720	68	87	79	72	1600	152	192	175	160
740	70	89	81	74	1620	154	195	178	162
760	72	91	83	76	1640	156	197	180	164
780	74	93	86	78	1660	158	199	182	166
800	76	96	88	80	1680	160	201	184	168
820	78	99	90	82	1700	162	204	187	170
840	80	101	92	84	1720	164	207	190	172
860	82	103	94	86	1740	165	209	192	174
880	84	105	97	88	1760	167	211	194	176

P.H.C.

RADIATION COMPUTING

Heating-Steam-
12" Brick Wall Lath, furring and plaster on inside.

Net Exp. Wall	Direct Radiation				Net Exp. Wall	Direct Radiation			
	S. or S.E.	N. or N.W.	W. or N.E.	E. or S.W.		S. or S.E.	N. or N.W.	W. or N.E.	E. or S.W.
20	2	2	2	2	900	86	108	99	90
40	4	5	4	4	920	87	111	101	92
60	6	7	7	6	940	89	113	103	94
80	8	10	9	8	960	91	115	105	96
100	10	12	11	10	980	93	117	108	98
120	11	14	13	12	1000	95	120	110	100
140	13	17	15	14	1020	97	123	112	102
160	15	19	18	16	1040	99	125	114	104
180	17	22	20	18	1060	101	127	116	106
200	19	24	22	20	1080	103	129	119	108
220	21	26	24	22	1000	105	132	121	110
240	23	29	26	24	1120	106	135	123	112
260	25	31	29	26	1140	108	137	125	114
280	27	34	31	28	1160	110	139	127	116
300	29	36	33	30	1180	112	141	131	118
320	30	38	35	32	1200	114	144	132	120
340	32	41	37	34	1220	116	147	134	122
360	34	43	40	36	1240	118	149	136	124
380	36	46	42	38	1260	120	151	138	126
400	38	48	44	40	1280	122	152	140	128
420	40	50	46	42	1300	124	156	143	130
440	42	53	48	44	1320	126	159	146	132
460	44	55	51	46	1340	127	161	147	134
480	46	58	53	48	1360	129	163	149	136
500	48	60	55	50	1380	131	165	151	138
520	49	62	57	52	1400	133	168	154	140
540	51	65	59	54	1420	135	171	156	142
560	53	67	62	56	1440	137	173	158	144
580	55	70	64	58	1460	139	175	160	146
600	57	72	66	60	1480	141	177	162	148
620	60	74	68	62	1500	143	180	164	150
640	61	77	70	64	1520	144	183	167	152
660	63	79	72	66	1540	146	185	169	154
680	65	81	75	68	1560	148	187	171	156
700	67	84	77	70	1580	150	189	173	158
720	68	87	79	72	1600	152	192	175	160
740	70	89	81	74	1620	154	195	178	162
760	72	91	83	76	1640	156	197	180	164
780	74	93	86	78	1660	158	199	182	166
800	76	96	88	80	1680	160	201	184	168
820	78	99	90	82	1700	162	204	187	170
840	80	101	92	84	1720	164	207	190	172
860	82	103	94	86	1740	165	209	192	174
880	84	105	97	88	1760	167	211	194	176

P.A.C.

RADIATION COMPUTING

Heating - Steam -
15" Brick Wall Lath, furring and plaster
on inside

Net Exp. wall	Direct Radiation				Net Exp. Wall.	Direct Radiation			
	S. or S.E.	N. or N.W.	W. or N.E.	E. or S.W.		S. or S.E.	N. or N.W.	W. or N.E.	E. or S.W.
20	2	2	2	2	900	77	94	86	81
40	3	4	4	4	920	78	96	88	83
60	5	6	6	5	940	80	98	89	85
80	7	8	8	7	960	82	100	91	86
100	9	11	10	19	980	84	102	93	88
120	10	13	11	11	1000	85	105	95	90
140	12	15	13	13	1020	87	107	97	92
160	14	17	15	14	1040	88	109	99	94
180	15	19	17	16	1060	90	111	101	95
200	17	21	19	18	1080	92	113	103	97
220	19	23	21	20	1100	94	115	105	99
240	20	25	23	22	1120	95	117	106	101
260	22	27	25	23	1140	97	119	108	102
280	24	29	27	25	1160	99	121	110	104
300	26	32	29	27	1180	101	123	112	106
320	27	34	30	29	1200	102	126	114	108
340	29	36	32	31	1220	103	128	116	110
360	31	38	34	32	1240	106	130	118	111
380	32	40	36	34	1260	107	132	120	113
400	34	42	38	36	1280	108	135	122	115
420	36	44	40	38	1300	110	137	124	117
440	37	46	42	40	1320	112	139	126	119
460	39	48	44	41	1340	113	141	127	120
480	41	50	46	43	1360	115	143	129	122
500	43	53	48	45	1380	117	145	131	124
520	44	55	50	47	1400	119	147	133	126
540	46	57	51	49	1420	120	149	135	128
560	48	59	53	50	1440	122	151	137	130
580	49	61	55	52	1460	124	153	139	131
600	51	63	57	54	1480	125	156	141	133
620	53	65	59	56	1500	127	158	143	135
640	54	67	61	58	1520	129	160	144	137
660	56	69	63	59	1540	130	162	146	138
680	58	71	65	61	1560	132	164	148	140
700	60	73	67	63	1580	134	166	150	142
720	61	75	68	65	1600	136	168	152	144
740	63	77	70	67	1620	137	169	154	146
760	65	79	72	68	1640	139	170	156	147
780	67	81	74	70	1660	141	172	158	149
800	68	84	76	72	1680	142	174	160	151
820	70	86	78	74	1700	144	177	162	153
840	71	88	80	76	1720	146	179	164	155
860	73	90	82	77	1740	147	181	166	156
880	75	92	84	79	1760	148	183	167	158

P.A.C

RADIATION COMPUTING—Steam Heating, 15-in. Brick Walls. NO. 13-J

RADIATION COMPUTING

Heating - Steam - 15" Brick Wall Lath, furring and plaster on inside

Net Exp. Wall	Direct Radiation				Net Exp. Wall.	Direct Radiation			
	S. or S.E.	N. or N.W.	W. or N.E.	E. or S.W.		S. or S.E.	N. or N.W.	W. or N.E.	E. or S.W.
20	2	2	2	2	900	77	94	86	81
40	3	4	4	4	920	78	96	88	83
60	5	6	6	5	940	80	98	89	85
80	7	8	8	7	960	82	100	91	86
100	9	11	10	19	980	84	102	93	88
120	10	13	11	11	1000	85	105	95	90
140	12	15	13	13	1020	87	107	97	92
160	14	17	15	14	1040	88	109	99	94
180	15	19	17	16	1060	90	111	101	95
200	17	21	19	18	1080	92	113	103	97
220	19	23	21	20	1100	94	115	105	99
240	20	25	23	22	1120	95	117	106	101
260	22	27	25	23	1140	97	119	108	102
280	24	29	27	25	1160	99	121	110	104
300	26	32	29	27	1180	101	123	112	106
320	27	34	30	29	1200	102	126	114	108
340	29	36	32	31	1220	103	128	116	110
360	31	38	34	32	1240	105	130	118	111
380	32	40	36	34	1260	107	132	120	113
400	34	42	38	36	1280	108	135	122	115
420	36	44	40	38	1300	110	137	124	117
440	37	46	42	40	1320	112	139	126	119
460	39	48	44	41	1340	113	141	127	120
480	41	50	46	43	1260	115	143	129	122
500	43	53	48	45	1380	117	145	131	124
520	44	55	50	47	1400	119	147	133	126
540	46	57	51	49	1420	120	149	135	128
560	48	59	63	50	1440	122	151	137	130
580	49	61	65	52	1460	124	153	139	131
600	51	63	57	54	1480	125	156	141	133
620	53	65	59	56	1500	127	158	143	135
640	54	67	61	58	1520	129	160	144	137
660	56	69	63	59	1540	130	162	146	138
680	58	71	65	61	1560	132	164	148	140
700	60	73	67	63	1580	134	166	150	142
720	61	75	68	65	1600	136	168	152	144
740	63	77	70	67	1620	137	169	154	146
760	65	79	72	68	1640	139	170	156	147
780	67	81	74	70	1660	141	172	158	149
800	68	84	76	72	1680	142	174	160	151
820	70	86	78	74	1700	144	177	162	153
840	71	88	80	76	1720	146	179	164	155
860	73	90	82	77	1740	147	181	166	156
880	75	92	84	79	1760	148	183	167	158

P.A.C

RADIATION COMPUTING—Steam Heating, 15-in. Brick Walls. NO. 13-J

RADIATION COMPUTING

Heating-Steam-
18" Brick Wall Lath furring and plaster on inside

Net Exp. Wall	Direct Radiation				Net Exp. Wall	Direct Radiation			
	S. or S.E.	N. or N.W.	W. or N.E.	E. or S.W.		S. or S.E.	N. or N.W.	W. or N.E.	E. or S.W.
20	2	2	2	2	900	68	86	77	72
40	3	4	3	3	920	69	88	79	74
60	5	6	5	5	940	71	90	81	76
80	6	8	7	6	960	72	92	83	78
100	8	10	9	8	980	74	94	84	79
120	9	11	10	10	1000	75	95	85	80
140	11	13	12	11	1020	77	97	87	82
160	12	15	14	13	1040	78	99	89	84
180	14	17	15	14	1060	80	101	91	86
200	15	19	17	16	1080	81	103	93	87
220	17	21	19	18	1100	83	105	94	88
240	18	23	20	19	1120	64	107	96	90
260	20	25	22	21	1140	86	109	98	92
280	21	27	24	22	1160	88	111	100	94
300	23	29	26	24	1180	89	113	101	95
320	24	30	27	26	1200	80	114	102	96
340	26	32	29	27	1220	92	116	104	98
360	27	34	31	29	1240	93	118	106	100
380	29	36	32	30	1260	95	120	108	102
400	30	38	34	32	1280	96	122	110	103
420	32	40	36	34	1300	98	124	111	104
440	33	42	37	35	1320	99	126	113	106
460	35	44	39	37	1340	101	128	115	108
480	36	46	41	38	1360	102	130	117	110
500	38	48	43	40	1380	104	132	118	111
520	39	50	44	42	1400	105	133	119	112
540	41	51	46	43	1420	107	135	121	114
560	42	53	48	45	1440	108	137	123	116
580	44	55	49	46	1460	110	139	125	118
600	45	57	51	48	1480	111	141	127	119
620	47	59	53	50	1500	113	143	128	120
640	48	61	54	52	1520	114	145	130	122
660	50	63	56	54	1540	116	147	132	124
680	51	65	58	55	1560	118	149	134	126
700	53	67	60	56	1580	119	151	135	127
720	54	69	62	58	1600	120	152	136	128
740	56	71	64	60	1620	122	154	138	130
760	58	73	66	62	1640	123	156	140	132
780	59	75	67	63	1660	125	158	142	134
800	60	76	68	64	1680	126	160	144	135
820	62	78	70	66	1700	128	162	145	136
840	63	80	72	68	1720	129	164	147	138
860	65	82	74	70	1740	131	166	149	140
880	66	84	76	71	1760	132	168	151	142

R.A.C.

RADIATION COMPUTING

Heating-Steam-
18" Brick Wall Lath furring and plaster on inside

Net Exp. Wall	Direct Radiation				Net Exp. Wall	Direct Radiation			
	S. or S.E.	N. or N.W.	W. or N.E.	E. or S.W.		S. or S.E.	N. or N.W.	W. or N.E.	E. or S.W.
20	2	2	2	2	900	68	86	77	72
40	3	4	3	3	920	69	88	79	74
60	5	6	5	5	940	71	90	81	76
80	6	8	7	6	960	72	92	83	78
100	8	10	9	8	980	74	94	84	79
120	9	11	10	10	1000	75	95	85	80
140	11	13	12	11	1020	77	97	87	82
160	12	15	14	13	1040	78	99	89	84
180	14	17	15	14	1060	80	101	91	86
200	15	19	17	16	1080	81	103	93	87
220	17	21	19	18	1100	83	105	94	88
240	18	23	20	19	1120	64	107	96	90
260	20	25	22	21	1140	86	109	98	92
280	21	27	24	22	1160	88	111	100	94
300	23	29	26	24	1180	89	113	101	95
320	24	30	27	26	1200	80	114	102	96
340	26	32	29	27	1220	92	116	104	98
360	27	34	31	29	1240	93	118	106	100
380	29	36	32	30	1260	95	120	108	102
400	30	38	34	32	1280	96	122	110	103
420	32	40	36	34	1300	98	124	111	104
440	33	42	37	35	1320	99	126	113	106
460	35	44	39	37	1340	101	128	115	108
480	36	46	41	38	1360	102	130	117	110
500	38	48	43	40	1380	104	132	118	111
520	39	50	44	42	1400	105	133	119	112
540	41	51	46	43	1420	107	135	121	114
560	42	53	48	45	1440	108	137	123	116
580	44	55	49	46	1460	110	139	125	118
600	45	57	51	48	1480	111	141	127	119
620	47	59	53	50	1500	113	143	128	120
640	48	61	54	52	1520	114	145	130	122
660	50	63	66	54	1540	116	147	132	124
680	51	65	58	55	1560	118	149	134	126
700	53	67	60	56	1580	119	151	135	127
720	54	69	62	58	1600	120	152	136	128
740	56	71	64	60	1620	122	154	138	130
760	58	73	66	62	1640	123	156	140	132
780	59	75	67	63	1660	125	158	142	134
800	60	76	68	64	1680	126	160	144	135
820	62	78	70	66	1700	128	162	145	136
840	63	80	72	68	1720	129	164	147	138
860	65	82	74	70	1740	131	166	149	140
880	66	84	76	71	1760	132	168	151	142

R.A.C.

RADIATION COMPUTING

Heating - Steam -
21" Brick Wall Lath furring and plaster on inside

Net	Direct Radiation				Net	Direct Radiation			
Exp. Wall.	S. or S.E.	N. or N.W.	W. or N.E.	E. or S.W	Exp. Wall.	S. or S.E	N or N.W.	W. or N.E.	E or S.W
20	1	2	2	2	900	63	76	72	68
40	3	3	3	3	20	64	78	74	69
60	4	5	5	5	40	66	80	76	70
80	6	7	6	6	60	68	82	77	72
100	7	9	8	8	80	69	84	79	74
120	8	10	10	9	1000	70	85	80	75
140	10	12	11	11	1020	71	86	82	77
160	11	14	13	12	1040	73	88	83	78
180	13	15	14	14	1060	75	90	86	80
200	14	17	16	15	1080	76	92	87	81
220	15	19	18	17	1100	77	93	88	82
240	17	20	19	18	1120	78	95	90	84
260	18	22	21	20	1140	80	97	91	85
280	20	24	22	21	1160	82	99	93	86
300	21	26	24	23	1180	83	101	95	88
320	22	27	26	24	1200	84	102	96	90
340	24	29	27	26	1220	86	104	98	92
360	25	31	29	27	1240	87	106	99	93
380	27	32	30	29	1260	89	108	101	95
400	28	34	32	30	1280	90	109	103	96
420	29	36	34	32	1300	91	110	104	97
440	31	37	35	33	1320	92	112	106	99
460	32	39	37	35	1340	94	114	107	101
480	34	41	38	36	1360	96	116	109	102
500	35	43	40	38	1380	97	118	111	104
520	36	44	42	39	1400	98	119	112	105
540	38	46	43	41	1420	99	121	114	107
560	39	48	45	42	1440	101	123	115	108
580	41	49	46	44	1460	103	125	117	110
600	42	51	48	45	1480	104	126	119	111
620	43	53	50	47	1500	105	121	124	112
640	45	55	52	48	1520	106	129	122	114
660	47	57	53	49	1540	108	131	123	115
680	48	58	55	50	1560	119	133	125	117
700	49	59	56	52	1580	111	135	127	119
720	50	60	58	54	1600	112	136	128	120
740	51	62	59	55	1620	113	138	130	122
760	53	64	61	57	1640	115	140	131	123
780	55	66	63	58	1660	117	142	133	125
800	56	68	64	60	1680	118	143	135	126
820	57	70	66	62	1700	119	144	136	127
840	59	72	67	63	1720	120	146	138	129
860	61	74	69	65	1740	122	148	139	130
880	62	75	71	66	1760	124	150	141	131

P.H.C.

RADIATOR COMPUTING—Steam Heating, 21-in. Brick Walls. NO. 13-L

RADIATION COMPUTING

Heating - Steam -

21" Brick Wall Lath furring and plaster on inside

Net	Direct Radiation				Net	Direct Radiation			
Exp. Wall.	S. or S.E.	N. or N.W.	W. or N.E.	E. or S.W.	Exp. Wall.	S. or S.E	N or N.W.	W. or N.E.	E or S.W
20	1	2	2	2	900	63	76	72	68
40	3	3	3	3	20	64	78	74	69
60	4	5	5	5	40	66	80	76	70
80	6	7	6	6	60	68	82	77	72
100	7	9	8	8	80	69	84	79	74
120	8	10	10	9	1000	70	85	80	75
140	10	12	11	11	1020	71	86	82	77
160	11	14	13	12	1040	73	88	83	78
180	13	15	14	14	1060	75	90	86	80
200	14	17	16	15	1080	76	92	87	81
220	15	19	18	17	1100	77	93	88	82
240	17	20	19	18	1120	78	95	90	84
260	18	22	21	20	1140	80	97	91	85
280	20	24	22	21	1160	82	99	93	86
300	21	26	24	23	1180	83	101	95	88
320	22	27	26	24	1200	84	102	96	90
340	24	29	27	26	1220	86	104	98	92
360	25	31	29	27	1240	87	106	99	93
380	27	32	30	29	1260	89	108	101	95
400	28	34	32	30	1280	90	109	103	96
420	29	36	34	32	1300	91	110	104	97
440	31	37	35	33	1320	92	112	106	99
460	32	39	37	35	1340	94	114	107	101
480	34	41	38	36	1360	96	116	109	102
500	35	43	40	38	1380	97	118	111	104
520	36	44	42	39	1400	98	119	112	105
540	38	46	43	41	1420	99	121	114	107
560	39	48	45	42	1440	101	123	115	108
580	41	49	46	44	1460	103	125	117	110
600	42	51	48	45	1480	104	126	119	111
620	43	53	50	47	1500	105	121	124	112
640	45	55	52	48	1520	106	129	122	114
660	47	57	53	49	1540	108	131	123	115
680	48	58	55	50	1560	119	133	125	117
700	49	59	56	52	1580	111	135	137	119
720	50	60	58	54	1600	112	136	128	120
740	51	62	59	55	1620	113	138	130	122
760	53	64	61	57	1640	115	140	131	123
780	55	66	63	58	1660	117	142	133	125
800	56	68	64	60	1680	118	143	135	126
820	57	70	66	62	1700	119	144	136	127
840	59	72	67	63	1720	120	146	138	129
860	61	74	69	65	1740	122	148	139	130
880	62	75	71	66	1760	124	150	141	131

P.A.C.

Heating - Steam

24" Brick Wall Lath furring and plaster on inside

Net	Direct Radiation				Net	Direct Radiation			
Exp. Wall.	S.or S.E.	N.or N.W.	Wor N.E.	E.or S.W.	Exp Wall.	S.or S.E.	N.or N.W.	W.or N.E.	E.or S.W.
20	1	2	1	1	900	54	68	63	59
40	2	3	3	3	920	55	69	65	60
60	4	5	4	4	940	56	71	67	62
80	5	6	6	5	960	58	72	68	63
100	6	8	7	7	980	59	74	69	64
120	7	9	8	8	1000	60	75	70	65
140	8	11	10	9	1020	61	77	72	67
160	10	12	11	10	1040	62	79	74	68
180	11	14	13	12	1060	64	80	75	69
200	12	15	14	13	1080	65	81	76	71
220	13	17	15	14	1100	66	83	77	72
240	14	19	17	16	1120	67	84	79	73
260	16	20	19	17	1140	68	86	81	74
280	17	21	20	18	1160	70	87	82	76
300	18	23	21	20	1180	71	89	83	77
320	19	24	22	21	1200	72	90	84	78
340	20	26	24	22	1220	73	92	86	79
360	22	27	25	23	1240	74	93	88	80
380	23	29	27	25	1260	76	95	89	82
400	24	30	28	26	1280	77	96	90	84
420	25	32	29	27	1300	78	98	91	85
440	26	33	31	29	1320	79	99	93	87
460	28	35	32	30	1340	80	101	95	88
480	29	36	34	31	1360	82	102	96	89
500	30	38	35	33	1380	83	104	97	90
520	31	39	36	34	1400	84	105	98	91
540	32	41	38	35	1420	85	107	100	93
560	34	42	39	36	1440	86	109	102	94
580	35	44	41	38	1460	88	110	103	95
600	36	45	42	39	1480	89	111	104	97
620	37	47	43	40	1600	90	113	105	98
640	38	49	45	41	1520	91	114	107	100
660	40	50	47	42	1540	92	116	109	101
680	41	51	48	44	1560	94	117	110	102
700	42	53	49	45	1580	95	119	111	103
720	43	54	51	46	1600	96	120	112	104
740	44	56	53	47	1620	97	122	114	106
760	46	57	54	48	1640	98	123	116	107
780	47	59	55	50	1660	100	125	117	108
800	48	60	56	52	1680	101	126	118	110
820	49	62	58	53	1700	102	128	119	111
840	50	63	60	54	1720	103	129	121	113
860	52	65	61	56	1740	104	131	123	114
880	53	66	62	58	1760	106	132	124	115

P. A. C

THE HEATING AND VENTILATING MAGAZINE—1123 BROADWAY, N. Y. CITY

Heating - Steam -
16" Stone or Concrete Wall Lath furring and plaster on inside

Net	Direct Radiation				Net	Direct Radiation			
Exp. Wall	S. or S.E.	N. or N.W.	W. or N.E.	E. or S.W.	Exp. Wall	S. or S.E.	N. or N.W.	W. or N.E.	E. or S.W.
20	3	4	3	3	900	126	158	144	136
40	6	7	6	6	920	129	161	147	138
60	8	11	10	9	940	132	165	150	141
80	11	14	13	12	960	134	168	154	144
100	14	18	16	15	980	137	172	157	147
120	17	21	19	16	1000	140	175	160	150
140	20	25	22	21	1020	143	179	163	153
160	22	28	26	24	1040	145	182	166	156
180	25	32	29	27	1060	148	186	170	159
200	28	35	32	30	1080	151	189	173	162
220	31	39	36	33	1100	154	193	176	165
240	34	42	38	36	1120	158	196	179	168
260	36	46	42	39	1140	161	200	182	171
280	39	49	45	42	1160	163	203	186	174
300	42	53	48	45	1180	166	207	189	177
320	45	56	51	48	1200	168	210	192	180
340	48	60	54	51	1220	171	214	195	183
360	50	63	58	54	1240	174	217	198	186
380	53	67	61	57	1260	176	221	202	189
400	56	70	64	60	1280	179	224	205	192
420	59	74	67	63	1300	182	228	208	195
440	62	77	70	66	1320	185	231	211	198
460	64	81	74	69	1340	188	235	214	201
480	67	84	77	72	1360	190	238	218	204
500	70	88	80	75	1380	193	242	221	207
520	73	91	83	78	1400	196	246	224	210
540	75	95	86	81	1420	199	249	227	213
560	78	98	90	84	1440	202	252	230	216
580	81	102	93	87	1460	204	256	234	219
600	84	105	96	90	1480	207	259	237	222
620	88	109	99	93	1500	210	263	240	225
640	91	112	102	96	1520	213	266	243	228
660	93	116	106	99	1540	215	270	246	231
680	95	119	109	102	1560	218	273	250	234
700	98	123	112	105	1580	221	277	253	237
720	101	126	116	108	1600	224	280	256	240
740	104	130	118	111	1620	228	284	259	243
760	106	133	122	114	1640	231	287	262	246
780	109	137	125	117	1660	233	291	266	249
800	112	140	128	120	1680	235	294	269	252
820	115	144	131	123	1700	238	298	272	255
840	118	147	134	126	1720	241	301	275	258
860	120	151	138	129	1740	244	305	278	261
880	123	154	141	132	1760	246	308	282	264

R.A.C.

RADIATION COMPUTING—Steam Htg., 16-in. Stone or Concrete Wall. NO. 13-N.

RADIATION COMPUTING.

Heating - Steam -
18" Stone or Concrete Wall Lath furring and plaster on inside

Net	Direct Radiation				Net	Direct Radiation			
Exp. wall	S. or S.E.	N. or N.W.	W. or N.E.	E. or S.W.	Exp. Wall	S. or S.E.	N. or N.W.	W. or N.E.	E. or S.W.
20	3	5	3	3	900	121	149	135	126
40	5	7	6	6	920	124	153	138	129
60	8	10	9	8	940	126	156	141	132
80	11	13	12	11	960	129	159	144	134
100	14	17	15	14	980	131	163	147	137
120	16	20	18	17	1000	134	166	150	140
140	19	23	21	20	1020	137	169	153	143
160	22	26	24	22	1040	139	172	156	146
180	24	30	27	25	1060	142	176	159	148
200	27	33	30	28	1080	145	179	162	151
220	30	36	33	31	1100	148	182	165	154
240	32	40	36	34	1120	150	186	168	157
260	35	43	39	37	1140	153	189	172	160
280	38	46	42	39	1160	156	193	175	162
300	41	50	45	42	1180	158	196	177	165
320	43	53	48	46	1200	161	199	180	168
340	46	56	51	48	1220	164	203	183	171
360	49	59	54	50	1240	166	205	186	174
380	51	63	57	53	1260	169	209	189	177
400	54	66	60	56	1280	171	212	192	179
420	57	69	63	59	1300	174	215	195	182
440	59	73	66	62	1320	177	219	198	185
460	62	76	69	64	1340	179	222	201	188
480	65	79	72	67	1360	182	226	204	190
500	68	83	75	70	1380	185	229	207	193
520	70	86	78	73	1400	188	232	210	196
540	73	89	81	76	1420	190	236	213	199
560	76	92	84	78	1440	193	239	216	202
580	78	96	87	81	1460	196	243	219	204
600	81	99	90	84	1480	198	246	222	207
620	84	102	93	87	1500	201	249	225	210
640	86	106	96	90	1520	204	253	228	213
660	89	109	99	92	1540	206	255	231	216
680	91	113	102	95	1560	209	259	234	218
700	94	116	105	98	1580	211	262	237	221
720	97	119	108	101	1600	215	264	240	223
740	99	123	111	104	1620	217	269	243	237
760	102	126	114	107	1640	219	272	246	240
780	105	129	117	109	1660	222	276	249	242
800	108	132	120	112	1680	225	279	252	245
820	110	136	123	115	1700	229	281	255	248
840	113	139	126	118	1720	230	286	258	251
860	116	142	129	120	1740	233	289	261	254
880	118	146	132	123	1760	236	293	264	257

P.M.C.

RADIATION COMPUTING.

Heating - Steam -
20" Stone or Concrete Wall. Loth furring and plaster on inside

Net Exp. Wall.	Direct Radiation				Net Exp. Wall	Direct Radiation			
	S. or S.E	N. or N.E	W. or N.E	E. or S.W		S. or S.E.	N. or N.W.	W. or N.E	E. or S.W.
20	3	3	3	3	900	113	144	130	121
40	5	6	6	5	920	115	147	133	124
60	8	10	9	8	940	118	150	135	126
80	10	13	12	11	960	120	154	138	129
100	13	16	15	14	980	123	167	141	131
120	15	19	17	16	1000	125	160	144	134
140	18	22	20	19	1020	128	163	147	137
160	20	26	23	22	1040	130	166	149	139
180	23	29	26	24	1060	133	170	152	142
200	25	32	29	27	1080	135	173	168	145
220	28	35	32	30	1100	138	176	158	148
240	30	38	35	32	1120	140	179	161	150
260	33	42	38	35	1140	143	182	164	153
280	35	45	41	38	1160	145	186	166	156
300	38	48	44	41	1180	148	189	164	158
320	40	51	46	43	1200	150	192	172	161
340	43	54	49	46	1220	153	195	175	164
360	45	58	52	49	1240	155	198	178	166
380	48	61	56	51	1260	158	202	181	169
400	50	64	58	54	1280	160	206	184	171
420	53	67	61	57	1300	163	208	187	174
440	55	70	64	59	1320	165	211	190	177
460	58	74	67	62	1340	168	214	193	179
480	60	77	70	65	1360	170	218	195	182
500	63	80	73	68	1380	173	221	198	185
520	65	83	75	70	1400	175	224	201	188
540	68	86	78	73	1420	178	227	204	190
560	70	90	81	76	1440	180	230	207	193
580	73	93	84	78	1460	183	234	209	196
600	75	96	87	81	1480	185	237	212	198
620	78	99	89	84	1500	188	240	215	201
640	80	102	92	86	1520	190	243	218	204
660	83	106	95	89	1540	193	246	221	206
680	85	109	98	91	1560	195	250	224	209
700	88	112	101	94	1580	198	253	226	211
720	90	115	104	97	1600	200	256	229	214
740	93	118	106	99	1620	203	259	232	217
760	95	122	109	102	1640	205	262	235	219
780	98	126	112	105	1660	208	266	238	222
800	100	128	115	108	1680	210	269	241	225
820	103	131	118	110	1700	213	272	244	228
840	105	134	121	113	1720	215	275	247	230
860	108	138	124	116	1740	217	278	250	233
880	110	141	127	118	1760	220	282	253	236

P.A.C.

RADIATION COMPUTING

Heating-Steam-
24" Stone or Concrete Wall. Lath furring and plaster on inside

Net Exp. Wall	Direct Radiation				Net Exp. Wall	Direct Radiation			
	S. or S.E.	N. or N.W.	W. or N.E.	E. or S.W.		S. or S.E	N. or N.W.	W. or N.E.	E. or S.W
20	2	3	3	2	900	99	126	117	108
40	4	6	5	5	920	101	129	120	110
60	7	8	8	7	940	103	132	122	113
80	9	11	10	10	960	106	134	125	115
100	11	14	13	12	980	108	137	127	118
120	13	17	16	14	1000	110	140	130	120
140	15	20	18	17	1020	112	143	133	122
160	18	22	21	19	1040	114	146	135	125
180	20	25	23	22	1060	117	148	138	127
200	22	28	26	24	1080	119	151	140	130
220	24	31	29	26	1100	121	164	143	132
240	26	34	31	29	1120	123	157	146	134
260	29	36	34	31	1140	126	160	148	137
280	31	39	36	34	1160	128	162	151	139
300	33	42	39	36	1180	130	165	153	142
320	35	45	42	38	1200	132	168	156	144
340	37	48	44	41	1220	134	171	159	146
360	40	50	47	43	1240	136	174	161	149
380	42	53	49	46	1260	139	176	164	151
400	44	56	52	48	1280	141	179	162	164
420	46	59	55	50	1300	143	182	165	156
440	48	62	57	53	1320	145	185	168	158
460	51	64	60	55	1340	147	188	170	161
480	53	67	62	58	1360	150	190	173	163
500	55	70	65	60	1380	152	193	176	166
520	57	73	68	62	1400	154	196	178	168
540	59	76	70	65	1420	156	199	181	170
560	62	78	73	67	1440	158	202	183	173
580	64	81	75	70	1460	161	204	186	175
600	66	84	78	72	1480	163	207	188	178
620	68	87	81	74	1500	165	210	191	180
640	70	90	83	77	1520	167	213	194	182
660	73	92	86	79	1540	170	216	196	185
680	75	95	88	82	1660	172	218	199	187
700	77	98	91	84	1580	174	221	201	190
720	79	101	94	86	1600	176	224	204	192
740	81	104	96	89	1620	178	227	207	194
760	84	106	99	91	1640	180	230	209	197
780	86	109	101	94	1660	183	232	212	199
800	88	112	104	96	1680	185	235	214	202
820	90	115	107	98	1700	187	238	217	204
840	92	118	109	101	1720	189	241	220	206
860	95	120	112	103	1740	191	244	222	209
880	97	123	114	106	1760	194	246	225	211

P.A.C.

RADIATION COMP.—Steam Htg., 24-in. Stone or Concrete Wall. No. 13-Q

RADIATION COMPUTING

Heating-Steam-
Windows-Single-Not weatherstripped

Net	Direct Radiation				Net	Direct Radiation			
Exp. Glass	S. or S.E.	N. or N.W.	W. or N.E.	E. or S.W.	Exp. Wall	S. or S.E.	N. or N.W.	W. or N.E.	E or S.W.
5	2	3	2	2	225	90	118	107	98
10	4	5	5	4	230	92	120	109	101
15	6	8	7	7	235	94	123	111	103
20	8	10	10	9	240	96	125	114	105
25	10	13	12	11	245	98	128	116	107
30	12	16	14	13	250	100	131	119	109
35	14	18	17	15	255	102	134	121	112
40	16	21	19	18	260	104	136	123	114
45	18	23	22	20	265	106	139	126	116
50	20	26	23	22	270	108	142	128	118
55	22	29	25	24	275	110	144	130	120
60	24	31	28	26	280	112	147	133	122
65	26	34	30	29	285	114	149	135	124
70	28	36	33	31	290	116	152	137	126
75	30	39	36	33	295	118	155	140	129
80	32	42	37	35	300	120	157	142	131
85	34	44	40	37	305	122	160	145	133
90	36	47	42	40	310	124	162	147	135
95	38	49	45	42	315	126	165	149	137
100	40	52	47	44	320	128	168	152	140
105	42	55	49	46	325	130	170	154	142
110	44	57	52	48	330	132	173	157	144
115	46	60	54	51	335	134	175	159	146
120	48	62	57	53	340	136	178	161	148
125	50	65	59	55	345	138	181	164	151
130	52	68	61	57	350	140	184	166	153
135	54	70	64	59	355	142	186	169	155
140	56	73	66	62	360	144	189	171	157
145	58	75	69	64	365	146	192	173	159
150	60	78	71	66	370	148	194	175	162
155	62	81	73	68	375	150	197	178	164
160	64	84	75	70	380	152	199	180	166
165	66	86	78	72	385	154	202	183	168
170	68	89	80	74	390	156	205	185	170
175	70	92	83	76	395	158	207	187	172
180	72	94	85	79	400	160	210	190	174
185	74	97	87	81	405	162	212	192	176
190	76	99	90	83	410	164	215	195	179
195	78	102	92	85	415	166	218	197	181
200	80	106	95	87	420	168	220	199	183
205	82	107	97	90	425	170	223	202	185
210	84	110	99	92	430	172	225	204	187
215	86	112	102	94	435	174	228	207	190
220	88	115	104	96	440	176	231	209	192

P.R.C.

RADIATION COMPUTING—Steam Heating, Single Windows. No. 13-R

RADIATION COMPUTING.

Heating-Hot Water.
12" Brick Wall Lath, furring and plaster on inside

Net	Direct Radiation				Net	Direct Radiation			
Exp. Wall.	S. or S.E.	N. or N.W.	W. or N.E.	E. or S.W.	Exp. Wall	S. or S.E.	N. or N.W.	W. or N.E.	E. or S.W.
20	3	4	4	3	900	144	180	167	142
40	6	8	7	7	920	147	184	170	145
60	10	12	11	10	940	150	188	174	149
80	13	16	15	14	960	154	192	178	152
100	16	20	19	17	980	167	196	181	155
120	19	24	22	20	1000	160	200	185	158
140	22	28	26	24	1020	163	204	189	162
160	26	32	30	27	1040	166	208	193	165
180	29	36	33	31	1060	170	212	196	169
200	32	40	37	34	1080	173	216	200	172
220	35	44	41	37	1100	176	220	204	175
240	38	48	44	41	1120	179	224	207	178
260	42	52	48	44	1140	182	228	211	182
280	45	56	52	48	1160	186	232	215	185
300	48	60	56	51	1180	189	236	219	189
320	51	64	59	54	1200	192	240	222	192
340	54	68	63	58	1220	196	244	226	195
360	58	72	67	61	1240	198	248	230	198
380	61	76	70	65	1260	202	252	233	202
400	64	80	74	68	1280	205	256	237	205
420	67	84	78	71	1300	208	260	241	209
440	70	88	81	75	1320	211	264	244	212
460	74	92	85	78	1340	214	268	248	215
480	77	96	89	82	1360	218	272	252	218
500	80	100	93	85	1380	221	276	256	222
520	83	104	96	88	1400	224	280	259	225
540	86	108	100	92	1420	227	284	263	229
560	90	112	104	95	1440	230	288	267	232
580	93	116	107	99	1460	234	292	270	235
600	96	120	111	102	1480	237	296	274	238
620	99	124	115	105	1500	240	300	278	242
640	102	128	119	108	1520	243	304	281	245
660	106	132	122	112	1540	246	308	285	249
680	109	136	126	115	1560	250	312	289	252
700	112	140	130	119	1580	253	316	293	265
720	115	144	133	122	1600	256	320	296	258
740	118	148	137	125	1620	259	324	300	262
760	122	152	141	128	1640	262	328	304	265
780	126	156	144	132	1660	266	332	307	269
800	128	160	148	135	1680	269	336	311	272
820	131	164	152	139	1700	272	340	315	275
840	134	168	156	142	1720	275	344	319	278
860	138	172	159	145	1740	278	348	322	282
880	141	176	163	148	1760	282	352	324	285

P.H.C.

RADIATION COMPUTING—Water Heating, 12-in. Brick Wall. | No. 13-S

THE HEATING AND VENTILATING MAGAZINE—1123 BROADWAY, N. Y. CITY

RADIATION COMPUTING.

Heating-Hot Water
15" Brick Wall Lath, furring and plaster on inside

Net Exp wall	Direct Radiation S. or S.E.	N. or N.W.	W. or N.E.	E. or S.W.	Net Exp. wall	Direct Radiation S. or S.E.	N. or N.W.	W. or N.E	E. or S.W.
20	3	4	3	3	900	126	158	144	136
40	6	7	6	6	920	129	162	147	138
60	8	11	10	9	940	132	165	150	141
80	11	14	13	12	960	134	169	154	144
100	14	18	16	15	980	137	172	157	147
120	17	21	19	18	1000	140	176	160	150
140	20	25	22	21	1020	143	179	163	158
160	22	28	26	24	1040	146	182	166	156
180	25	32	29	27	1060	148	186	170	159
200	28	35	32	30	1080	151	189	173	162
220	31	39	35	33	1100	154	193	176	165
240	34	42	38	36	1120	157	196	179	168
260	36	46	42	39	1140	160	200	182	171
280	39	49	45	42	1160	162	203	186	174
300	42	53	48	45	1180	165	207	189	177
320	45	56	51	48	1200	168	210	192	180
340	48	60	54	51	1220	171	214	195	183
360	50	63	58	54	1240	174	217	198	186
380	53	67	61	57	1260	176	221	202	189
400	56	70	64	60	1280	179	226	205	192
420	59	74	67	63	1300	182	228	208	195
440	62	77	70	66	1320	185	232	211	198
460	64	81	74	69	1340	188	235	214	201
480	67	85	77	72	1360	190	239	218	204
500	70	88	80	75	1380	198	242	221	207
520	73	92	83	78	1400	196	246	224	210
540	76	95	86	81	1420	199	249	227	213
560	78	99	90	84	1440	202	252	230	216
580	81	102	93	87	1460	204	256	234	219
600	84	106	96	90	1480	207	269	237	222
620	87	109	99	93	1500	210	263	240	225
640	90	112	102	96	1520	213	266	243	228
660	92	116	106	99	1540	216	270	246	231
680	95	119	109	102	1560	218	273	250	234
700	98	123	112	105	1580	221	277	253	237
720	101	126	115	108	1600	224	280	256	240
740	104	130	118	111	1620	227	284	259	243
760	106	133	122	114	1640	230	287	262	246
780	109	137	125	117	1660	232	291	266	249
800	112	140	128	120	1680	235	295	269	252
820	115	144	131	123	1700	238	298	272	255
840	118	147	134	126	1720	241	302	275	258
860	120	151	138	129	1740	244	306	278	261
880	123	155	141	132	1760	246	309	282	264

P.A.C.

RADIATION COMPUTING—Water Heating, 15-in. Brick Wall. No. 13-T

RADIATION COMPUTING.

Heating-Hot Water-
18" Brick Wall Lath, furring and plaster on inside

Net Exp. Wall	Direct Radiation				Net Exp. Wall	Direct Radiation			
	S. or S.E.	N. or N.W.	W. or N.E	E. or S.W.		S. or S.E.	N. or N.W.	W. or N.E.	E. or S.W.
20	3	3	3	3	900	113	144	131	123
40	5	6	6	5	920	116	147	134	126
60	8	10	9	8	940	118	150	137	129
80	10	13	12	11	960	120	154	140	131
100	13	16	15	14	980	123	157	143	134
120	16	19	17	16	1000	125	160	145	137
140	18	22	20	19	1020	128	163	148	139
160	20	26	23	22	1040	130	166	151	142
180	23	29	26	24	1060	133	170	154	144
200	25	32	29	27	1080	135	173	157	147
220	28	35	32	30	1100	138	176	160	150
240	30	38	35	32	1120	140	179	163	152
260	33	42	38	35	1140	143	182	166	155
280	35	45	41	38	1160	145	186	169	158
300	38	48	44	42	1180	148	189	172	162
320	40	51	46	44	1200	150	192	175	164
340	43	54	49	47	1220	153	195	178	167
360	45	58	52	50	1240	155	198	181	170
380	48	61	55	52	1260	158	202	184	172
400	50	64	58	65	1280	160	205	186	175
420	53	67	61	58	1300	163	208	189	178
440	55	70	64	60	1320	165	211	192	180
460	58	74	67	63	1340	168	214	195	183
480	60	77	70	66	1360	170	218	198	186
500	63	80	73	69	1380	173	221	201	189
520	65	83	75	71	1400	175	224	204	191
540	68	86	78	74	1420	178	227	207	194
560	70	90	81	77	1440	180	230	210	197
580	73	93	84	79	1460	183	234	213	199
600	75	96	87	82	1480	185	237	215	202
620	78	99	90	84	1500	188	240	218	204
640	80	102	93	87	1520	190	243	221	207
660	83	106	96	90	1540	193	246	224	210
680	85	109	99	92	1560	195	250	227	212
700	88	112	102	95	1580	198	253	230	215
720	90	115	105	98	1600	200	256	233	218
740	93	118	108	102	1620	203	259	236	222
760	95	122	111	104	1640	205	262	239	224
780	98	125	114	107	1660	208	266	242	227
800	100	129	116	110	1680	210	269	245	230
820	103	131	119	112	1700	213	272	248	232
840	105	134	122	115	[illegible]	215	275	251	235
860	108	138	126	118	1740	218	278	254	238
880	110	141	128	120	1760	220	282	256	240

P.H.C.

RADIATION COMPUTING—Water Heating, 18-In. Brick Wall. No. 13-U.

THE HEATING AND VENTILATING MAGAZINE—1123 BROADWAY, N. Y. CITY

RADIATION COMPUTING.

Heating - Hot Water -
21" Brick Wall Lath, furring and plaster on inside

Net Exp. Wall	Direct Radiation S. or S.E.	N. or N.W.	W. or N.E.	E. or S.W.	Net Exp. Wall	Direct Radiation S. or S.E.	N. or N.W.	W. or N.E.	E. or S.W.
20	3	3	3	2	900	104	126	117	108
40	5	6	5	5	920	106	129	120	110
60	7	8	8	7	940	108	132	122	113
80	9	11	10	10	960	111	134	125	116
100	12	14	13	12	980	113	137	128	118
120	14	17	16	14	1000	115	140	130	120
140	16	20	18	17	1020	118	143	133	122
160	18	22	21	19	1040	120	146	135	125
180	21	25	23	22	1060	122	148	138	127
200	23	28	26	24	1080	124	151	141	130
220	26	31	29	26	1100	127	154	143	132
240	28	34	31	29	1120	129	157	146	134
260	30	36	34	31	1140	131	160	149	137
280	32	39	36	34	1160	134	162	151	139
300	35	42	39	36	1180	136	165	154	142
320	37	45	42	38	1200	138	168	156	144
340	39	48	44	41	1220	141	171	159	146
360	42	50	47	43	1240	143	174	162	149
380	44	53	49	46	1260	145	176	164	151
400	46	56	52	48	1280	148	179	167	154
420	48	59	55	50	1300	150	182	169	156
440	51	62	57	53	1320	152	185	172	158
460	53	64	60	56	1340	155	188	175	161
480	55	67	62	58	1360	157	190	177	163
500	58	70	65	60	1380	159	193	180	166
520	60	73	68	62	1400	162	196	182	168
540	62	76	70	65	1420	164	199	185	170
560	64	78	73	67	1440	166	202	188	173
580	67	81	75	70	1460	168	204	190	176
600	69	84	78	72	1460	171	207	193	178
620	71	87	81	74	1500	173	210	195	180
640	74	90	83	77	1520	175	213	198	182
660	76	92	86	79	1540	178	216	201	185
680	76	95	89	82	1560	180	218	203	187
700	81	98	91	84	1580	182	221	206	190
720	83	101	94	86	1600	184	224	209	192
740	85	104	96	89	1620	187	227	211	194
760	88	106	99	91	1640	189	230	214	197
780	90	109	102	94	1660	191	232	216	199
800	92	112	104	96	1680	194	235	219	202
820	95	115	107	98	1700	196	238	222	204
840	97	118	109	101	1720	198	241	224	206
860	99	120	112	103	1740	201	244	227	209
880	102	123	116	106	1760	203	246	229	211

B.H.L.

RADIATION COMPUTING—Water Heating, 21-In. Brick Wall. No. 13-V.

RADIATION COMPUTING.

Heating Hot Water
24" Brick Wall Lath, furring and plaster on inside

Net Exp. Wall	Direct Radiation				Net Exp. Wall.	Direct Radiation			
	S. or S.E.	N. or N.W.	W. or N.E.	E. or S.W.		S. or S.E.	N. or N.W.	W. or N.E.	E. or S.W.
20	2	3	2	2	900	90	117	108	99
40	4	5	5	4	920	92	120	110	102
60	6	8	7	7	940	94	122	112	104
80	8	10	9	9	960	96	126	115	106
100	10	13	12	11	980	98	128	117	108
120	12	16	14	13	1000	100	130	120	111
140	14	18	17	15	1020	102	133	122	113
160	16	21	19	18	1040	104	135	124	115
180	18	23	22	20	1060	106	138	126	117
200	20	26	24	22	1080	108	141	129	119
220	22	29	26	24	1100	110	143	131	121
240	24	31	29	26	1120	112	146	134	124
260	26	34	31	29	1140	114	149	136	126
280	28	36	34	31	1160	116	151	138	128
300	30	39	36	33	1180	118	154	141	131
320	32	42	38	35	1200	120	156	143	133
340	34	44	41	37	1220	122	159	146	135
360	36	47	43	40	1240	124	162	148	137
380	38	49	46	42	1260	126	164	160	139
400	40	52	48	44	1280	128	167	153	142
420	42	55	50	46	1300	130	169	155	144
440	44	57	53	48	1320	132	172	158	146
460	46	60	55	51	1340	134	175	160	148
480	48	62	58	53	1360	136	177	162	151
500	50	65	60	55	1380	138	180	166	153
520	52	68	62	57	1400	140	182	167	155
540	54	70	65	59	1420	142	185	170	157
560	56	73	67	62	1440	144	188	172	159
580	58	75	70	64	1460	146	190	174	162
600	60	78	72	66	1480	148	193	176	164
620	62	81	74	68	1500	150	196	179	166
640	64	83	76	71	1520	152	198	181	168
660	66	86	79	73	1540	154	201	184	171
680	68	89	81	75	1560	156	203	186	173
700	70	91	84	77	1580	158	206	188	175
720	72	94	86	79	1600	160	209	191	177
740	74	96	88	82	1620	162	211	193	179
760	76	99	91	84	1640	164	214	196	182
780	78	102	93	86	1660	166	216	198	184
800	80	104	96	88	1680	168	219	200	186
820	82	107	98	91	1700	170	222	203	189
840	84	109	100	93	1720	172	224	205	191
860	86	112	103	95	1740	174	227	208	193
880	88	115	105	97	1760	176	229	210	195

P.H.C.

RADIATION COMPUTING—Water Heating, 24-In. Brick Wall. No. 13-W.

7
H-5.2
v.1 pt.2

THE HEATING AND VENTILATING MAGAZINE—1123 BROADWAY, N. Y. CITY

RADIATION COMPUTING.

Heating-Hot Water
16" Stone or Concrete Wall. Lath, furring and plaster on inside

Net. Exp. wall	Direct Radiation S. or S.E.	N. or N.W	W. or N.E	E. or S.W.	Net Exp. Wall	Direct Radiation S. or S.E	N. or N.W.	W. or N.E.	E. or S.W
20	5	6	5	5	900	212	263	243	225
40	9	12	11	10	920	216	269	248	230
60	14	17	16	15	940	220	275	254	235
80	19	23	22	20	960	226	280	259	240
100	24	29	27	25	980	230	286	265	245
120	28	35	32	30	1000	235	292	270	250
140	33	41	38	35	1020	240	298	275	255
160	38	46	43	40	1040	244	304	281	260
180	42	52	49	45	1060	249	309	296	265
200	47	58	54	50	1080	254	316	291	270
220	52	64	59	55	1100	259	321	297	275
240	56	70	65	60	1120	263	327	302	280
260	61	75	70	65	1140	268	333	308	285
280	66	81	76	70	1160	273	338	314	290
300	71	87	81	75	1180	277	344	320	295
320	75	94	86	80	1200	282	350	324	300
340	80	100	92	85	1220	286	356	329	305
360	85	105	97	90	1240	291	362	335	310
380	89	112	103	95	1260	296	367	340	315
400	94	118	108	100	1280	301	373	346	320
420	99	124	113	105	1300	306	379	351	326
440	103	130	119	110	1320	310	385	356	330
460	108	135	124	115	1340	315	391	362	335
480	113	141	130	120	1360	320	396	367	340
500	118	147	135	125	1380	324	402	373	345
520	122	153	140	130	1400	329	408	378	350
540	126	159	146	135	1420	334	414	383	355
560	132	164	151	140	1440	338	420	389	360
580	136	170	157	145	1460	343	425	394	365
600	141	176	162	150	1480	348	431	400	370
620	146	182	167	155	1500	353	437	405	375
640	150	188	173	160	1520	357	443	410	380
660	155	193	178	165	1540	362	449	416	385
680	160	199	184	170	1560	366	454	421	390
700	164	205	189	175	1580	371	460	427	395
720	169	211	194	180	1600	376	466	432	400
740	174	217	200	185	1620	381	472	437	406
760	179	222	205	190	1640	385	478	443	410
780	183	228	211	195	1660	390	483	448	415
800	188	234	216	200	1680	395	489	454	420
820	193	240	221	205	1700	400	495	459	425
840	197	246	227	210	1720	404	501	464	430
860	202	231	232	215	1740	409	506	470	435
880	207	257	238	220	1760	414	511	475	440

P.A.C.

RADIATION COMPUTING—Water Htg., 16-in. Stone or Concrete Wall No. 13-X

ALTGELD HALL

THE HEATING AND VENTILATING MAGAZINE—1133 BROADWAY, N. Y. CITY

RADIATION COMPUTING.

Heating · Hot Water
18" Stone or Concrete Wall. Lath, furring and plaster on inside

Net Exp. wall	Direct Radiation				Net Exp wall	Direct Radiation			
	S. or S.E	N. or N.W	W. or N.E	E. or S.W		S. or S.E	N. or N.W	W. or N.E	E. or S.W.
20	4	6	5	5	900	188	248	231	214
40	9	11	10	9	920	192	253	236	218
60	13	17	15	14	940	197	259	241	223
80	18	22	20	19	960	201	264	246	228
100	22	28	26	24	980	206	270	251	232
120	26	33	31	29	1000	210	275	257	237
140	31	39	36	33	1020	214	283	262	242
160	35	44	41	38	1040	219	288	267	247
180	40	50	46	43	1060	223	294	272	251
200	44	55	51	47	1080	228	299	277	256
220	48	61	56	52	1100	232	306	283	261
240	53	66	61	57	1120	236	310	288	265
260	57	72	66	61	1140	241	315	293	270
280	62	77	71	66	1160	245	320	298	275
300	66	83	77	71	1180	250	326	303	279
320	70	88	82	76	1200	254	332	309	284
340	75	94	87	80	1220	259	338	314	289
360	79	99	92	85	1240	263	344	219	294
380	84	105	97	90	1260	268	350	324	295
400	88	110	102	94	1280	274	355	329	303
420	92	116	107	100	1300	280	360	335	308
440	97	121	112	105	1320	286	365	340	312
460	101	127	117	109	1340	289	370	345	317
480	106	132	122	114	1360	294	375	350	322
500	110	138	128	119	1380	298	381	355	326
520	114	143	133	124	1400	302	387	361	331
540	119	149	138	128	1420	307	393	366	336
560	123	154	143	133	1440	311	399	371	341
580	128	160	148	138	1460	316	405	376	345
600	132	165	153	142	1480	320	410	381	350
620	136	171	158	147	1500	324	415	387	355
640	141	176	163	152	1520	329	420	392	359
660	145	182	168	156	1540	333	426	397	364
680	150	187	173	161	1560	338	432	402	369
700	154	193	179	166	1580	342	438	407	373
720	158	198	184	170	1600	346	444	413	378
740	163	204	189	175	1620	351	448	418	382
760	167	209	194	180	1640	355	453	423	388
780	172	215	199	184	1660	360	458	428	392
800	176	220	205	189	1680	364	463	433	397
820	180	226	210	194	1700	368	468	438	402
840	185	231	216	199	1720	373	475	444	406
860	189	237	220	204	1740	377	481	449	411
880	194	242	225	209	1760	382	487	454	416

P.A.C.

RADIATION COMPUTING—Water Htg., 18-in. Stone or Concrete Wall. No. 13-Y.

RADIATION COMPUTING.

Heating - Hot Water
20" Stone or Concrete Wall Lath furring and plaster on inside

Net Exp wall	Direct Radiation				Net Exp. Wall	Direct Radiation			
	S. or S:E	N. or N.W	W. or N.E	E. or S.W.		S. or S.E	N. or N.W	W. or N.E.	E. or S.W.
20	4	5	5	6	900	189	233	216	203
40	8	10	10	9	920	193	237	221	206
60	13	16	14	14	940	197	242	225	211
80	17	21	19	18	960	201	248	230	215
100	21	26	24	23	980	205	253	235	220
120	25	31	29	27	1000	210	259	240	225
140	29	36	34	32	1020	214	263	245	220
160	34	42	38	36	1040	218	268	249	233
180	38	47	43	41	1060	222	274	254	237
200	42	52	48	45	1080	226	279	259	242
220	46	57.	53	50	1100	331	285	264	248
240	50	62	58	54	1120	235	289	269	251
260	55	68	62	59	1140	239	294	273	256
280	59	73	67	63	1160	243	300	278	260
300	63	78	72	68	1180	247	306	283	265
320	67	83	77	72	1200	252	311	288	270
340	77	88	82	77	1220	256	315	293	273
360	76	94	86	81	1240	260	320	297	278
380	80	99	91	86	1260	264	326	302	282
400	84	104	96	90	1280	268	331	307	287
420	88	109	101	95	1300	273	337	312	293
440	92	114	106	99	1320	277	341	317	296
460	97	120	110	104	1340	281	346	321	301
480	101	125	115	108	1360	285	347	326	305
500	105	130	120	113	1380	289	352	331	310
520	109	135	125	117	1400	294	363	336	315
540	113	139	130	122	1420	298	367	341	318
560	118	146	134	126	1440	302	370	345	323
580	122	150	139	131	1460	306	374	350	327
600	126	155	144	135	1480	310	379	355	332
620	130	159	149	140	1500	315	385	360	338
640	134	164	154	144	1520	319	392	365	341
660	138	120	158	149	1540	323	398	369	346
680	143	175	163	153	1560	327	404	374	350
700	147	181	168	158	1580	331	409	379	355
720	151	185	173	163	1600	336	416	384	360
740	155	190	177	166	1620	340	419	389	363
760	159	196	182	171	1640	344	424	394	368
780	163	201	187	175	1660	348	430	398	372
800	168	207	192	160	1680	352	436	403	377
820	172	211	197	183	1700	357	441	408	383
840	176	216	201	188	1720	361	446	413	386
860	180	223	206	192	1740	365	450	417	391
880	184	228	211	197	1760	369	456	422	395

E. A. C.

RADIATION COMPUTING—Water Htg., 20-in. Stone or Concrete Wall. No. 13-Z.

RADIATION COMPUTING.

Heating - Hot Water

24" Stone or Concrete Wall. Lath furring and plaster on inside

Net	Direct Radiation				Net	Direct Radiation			
Exp. Wall.	S. or S.E	N. or N.W.	W. or N.E.	E. or S.W.	Exp. Wall.	S. or S.E	N. or N.W.	W. or N.E.	E or S.W
20	4	5	4	4	900	167	207	200	176
40	7	9	9	8	920	171	212	204	180
60	11	14	13	12	940	174	216	209	184
80	15	18	17	16	960	178	221	213	188
100	19	23	22	20	980	182	225	217	192
120	22	28	26	23	1000	185	230	223	195
140	26	32	30	27	1020	189	236	227	199
160	30	37	34	31	1040	192	239	232	203
180	33	41	39	35	1060	196	244	236	207
200	37	46	43	39	1080	200	248	240	211
220	41	51	47	43	1100	204	253	245	215
240	44	55	52	47	1120	208	258	249	219
260	48	60	56	51	1140	211	262	254	223
280	52	64	60	55	1160	215	267	258	227
300	56	69	65	59	1180	219	271	262	231
320	59	74	69	62	1200	222	276	268	234
340	63	78	73	66	1220	226	281	272	238
360	67	83	77	70	1240	229	285	277	242
380	70	87	82	74	1260	233	290	281	246
400	74	92	86	78	1280	237	294	285	250
420	78	97	90	82	1300	141	299	290	254
440	81	101	95	86	1320	145	304	294	258
460	85	106	100	90	1340	148	308	299	262
480	89	110	104	94	1360	152	313	303	266
500	93	115	109	98	1380	156	317	307	270
520	96	120	113	101	1400	159	322	313	273
540	100	124	117	105	1420	163	327	317	277
560	104	129	121	109	1440	166	331	322	281
580	107	133	126	113	1460	170	336	326	285
600	111	138	130	117	1480	174	340	330	289
620	115	143	134	121	1500	178	345	335	293
640	119	147	139	125	1520	182	350	339	297
660	122	152	143	129	1540	185	354	344	301
680	126	156	147	133	1560	189	359	348	305
700	130	161	165	137	1580	193	363	252	309
720	134	166	169	141	1600	196	368	358	312
740	137	170	164	145	1620	200	373	362	316
760	141	175	168	149	1640	203	377	367	320
780	146	179	172	153	1660	207	382	371	324
800	148	184	177	156	1680	211	386	375	328
820	152	189	181	160	1700	215	391	380	332
840	156	193	185	164	1720	219	396	384	336
860	159	198	200	168	1740	222	400	389	340
880	163	202	204	172	1760	226	404	393	344

R.A.C.

RADIATION COMPUTING—Water Htg., 24-in. Stone or Concrete Wall. No. 13-AA.

RADIATION COMPUTING.

Heating - Hot Water

Windows - Single - Not Weather stripped

Divide Rad. by 2 if storm sash are used

Net Exp Glass	Direct Radiation				Net Exp Glass	Direct Radiation			
	S. or S.E.	N. or N.W.	W. or N.E.	E. or S.W.		S. or S.E.	N. or N.W.	W. or N.E.	E. or S.W.
5	3	4	4	4	225	152	194	180	167
10	7	9	8	7	230	155	198	184	171
15	10	13	12	11	235	159	203	188	174
20	14	17	16	15	240	162	207	192	178
25	17	22	20	19	245	166	211	196	182
30	20	26	24	22	250	169	215	200	185
35	24	30	28	26	255	172	219	204	189
40	27	34	32	30	260	176	224	208	192
45	31	39	36	33	265	179	228	212	196
50	34	43	40	37	270	183	232	216	200
55	37	47	44	41	275	186	237	220	204
60	41	52	48	44	280	189	241	224	208
65	44	56	52	48	285	193	246	228	211
70	48	60	56	52	290	196	250	232	215
75	51	65	60	56	295	200	254	236	219
80	54	69	64	59	300	203	258	240	222
85	57	73	68	63	305	206	262	244	226
90	61	78	72	66	310	210	267	248	229
95	65	82	76	70	315	213	271	252	233
100	68	86	80	74	320	217	275	256	237
105	71	90	84	78	325	220	280	260	241
110	75	95	88	81	330	223	284	264	245
115	78	99	92	85	335	227	289	268	248
120	82	103	96	89	340	230	293	272	252
125	84	108	100	93	345	234	297	276	256
130	87	112	104	96	350	237	301	280	259
135	91	116	108	100	355	240	305	284	263
140	94	121	112	104	360	244	310	288	266
145	98	125	116	107	365	247	314	292	270
150	101	129	120	111	370	251	318	296	274
155	104	134	124	115	375	254	323	300	278
160	108	139	128	119	380	257	327	304	282
165	111	143	132	122	385	261	332	308	285
170	115	147	136	126	390	264	336	312	289
175	118	151	140	130	395	268	340	316	293
180	120	155	144	134	400	271	344	320	296
185	122	160	148	137	405	274	348	324	360
190	125	164	152	141	410	278	353	328	304
195	129	168	156	145	415	281	357	332	307
200	135	172	160	148	420	285	361	336	311
205	138	176	164	152	425	288	366	340	315
210	142	181	168	155	430	291	370	344	319
215	145	185	172	159	435	295	375	348	322
220	149	189	176	163	440	298	329	352	326

.R.A.C.

RADIATION COMPUTING—Water Heating, Single Windows.

No. 13-BB.

RADIATION COMPUTING.

Heating-Steam-Indirect.

For converting direct radiation to indirect, Flue sizes. etc.

Direct Rad		Equiv. indirect 40" Reg. Vento 4" ℄			Flue area in sq. inches			Register area
Stone or Concrete Walls	Brick Walls	Weight of air p/h in lbs. For htg Temp 115-70° " 0-120°	Total No. Sections	Ind. Rad. 1-Section deep 4" Centres	1st. Floor V.=180 f/m	2nd. Floor V.=300 f/m.	Vel. at 240. f/m.	Gr. area at 180 f/m Thru. free area.
14	15	304	2	21.50	60	36	48	100
21	22	455	3	32.25	90	54	72	150
27	29	606	4	43	120	72	96	200
34	36	757	5	53.75	150	90	120	250
40	43	908	6	64.50	180	108	144	300
47	50	1059	7	75.25	210	126	168	350
53	57	1210	8	86	240	144	192	400
60	64	1361	9	96.75	270	162	177	450
66	71	1512	10	107.50	300	180	240	500
73	78	1663	11	118.25	330	198	264	550
80	85	1814	12	129.00	360	216	288	600
86	92	1965	13	139.75	390	234	312	650
93	99	2116	14	150.50	420	252	346	700
99	106	2267	15	161.25	450	270	360	750
105	113	2418	16	172	480	284	386	800
112	120	2569	17	182.75	510	302	404	850
119	127	2720	18	193.50	540	320	432	900
125	134	2871	19	204.25	570	338	456	950
132	141	3022	20	215	600	396	480	1000
138	148	3173	21	225.75	630	374	508	1050
145	155	3324	22	236.50	660	392	528	1100
151	162	3475	23	247.25	690	410	554	1150
158	169	3625	24	258	720	428	576	1200
164	176	3777	25	268.75	750	446	600	1250
171	183	3928	26	279.50	780	464	623	1300
177	190	4079	27	290.25	810	482	650	1350
184	197	4230	28	301	840	500	672	1400
190	204	4381	29	311.75	870	518	646	1450
197	211	4532	30	322.50	900	536	720	1500
204	218	4683	31	333.25	930	554	744	1650
211	225	4834	32	344	960	572	768	1600
218	232	4985	33	354.75	990	590	792	1650
225	239	5136	34	365.5	1020	608	816	1700
232	246	5287	35	376.25	1050	626	840	1750
239	253	5438	36	387.00	1080	644	864	1800
246	260	5589	37	397.75	1110	660	888	1850
251	267	5740	38	408.50	1140	680	912	1900
258	274	5891	39	419.25	1170	698	934	1950
266	281	6042	40	430.	1200	716	960	2000
272	288	6143	41	441.75	1230	734	984	2050

P.A.C.

RADIATION COMPUTING.

Heating-Hot Water-Indirect

For converting direct radiation to indirect. Flue sizes. etc.

Direct Rad.		Equiv. indirect 40" Reg. Vento 4"℄			Flues-area in sq. in.			Reg. Gr. area
Stone or Concrete walls	Brick walls	Weight of air p/h in lbs. For htg. Temp. 115-70° " 0-120	Total No Sections	Ind. Rad. 2-Sections deep 4" Centres	1st. Floor V=180 f/m.	2nd. Floor V=300 f/m	Vel. of 240 f/m.	Gr. area of 120 f/m Thru free area.
26	28	348	4	43	67	40	54	110
39	42	522	6	64.5	100	60	84	165
52	56	696	8	86	135	80	108	220
65	70	870	10	107.5	168	100	134	275
78	84	1044	12	129	201	120	165	330
91	98	1218	14	150.5	234	140	187	385
104	112	1392	16	172	267	160	214	440
117	126	1566	18	193.5	300	180	240	495
130	140	1740	20	215	333	200	267	550
143	154	1914	22	236.5	366	220	293	605
156	168	2088	24	258	399	240	320	660
169	182	2262	26	279.5	432	260	346	715
182	196	2436	28	301	465	280	373	770
195	210	2610	30	322.5	498	300	399	825
208	224	2784	32	344	531	320	426	880
221	238	2958	34	365.5	564	340	452	935
234	252	3132	36	387	597	360	479	990
247	266	3306	38	408.5	630	380	505	1045
260	280	3480	40	430	663	400	532	1100
273	294	3654	42	451.5	696	420	558	1155
286	308	3828	44	473	729	440	585	1210
299	322	4002	46	494.5	762	460	611	1265
312	336	4176	48	516	795	480	637	1320
325	350	4350	50	537.5	828	500	664	1375
338	364	4524	52	559	861	520	691	1430
331	378	4698	54	580.5	894	540	637	1485
364	392	4862	56	602	937	560	749	1540
377	406	5036	58	623.5	970	580	775	1595
390	420	5210	60	645	1003	600	802	1650
403	434	5384	62	666.5	1036	620	828	1705
416	448	5554	64	688	1069	640	855	1760
429	462	5724	66	709.5	1102	660	881	1815
432	476	5894	68	730	1135	680	908	1870
445	490	6064	70	751.5	1168	700	934	1925
458	504	6234	72	773	1201	720	962	1980
471	518	6404	74	794.5	1234	740	987	2035
484	532	6574	76	816	1267	760	1014	2090
487	546	6744	78	837.5	1300	780	1040	2145
500	557	6914	80	859	1333	800	1067	2200
513	573	7084	82	881.5	1366	820	1093	2255

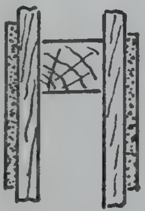
P.A.C.

RADIATION COMPUTING.

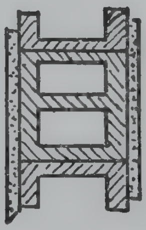
Heating-Steam-Partitions-

Radiation to compensate for Heat Losses through various partitions. Temp. dif. 30°

Area in sq. ft.	Direct steam Radiation				
	$A-A_1$	$B-B_1$	C	$D-D_1$	
60	4	3	2	2	
80	5	4	3	2	
100	6	4	4	3	
120	7	5	4	3	
140	8	6	5	4	
160	10	7	6	4	
180	11	8	7	5	
200	12	9	7	5	
220	13	10	8	6	
240	14	11	9	6	
260	16	12	10	7	
280	17	13	11	7	



Wood



Hollow tile

A = Plaster-1-side   C = Plaster-2-sides
B = " -2- "
B_1 = 8" Brick Plastered
D_1 = Expanded metal, plaster 2 sides, asbestos fill.
A_2 = " " " 2 " air space
D = Double hollow tile air space and plaster both sides.

RADIATION COMPUTING.

Heating-Hot Water-Partitions.

Radiation to compensate for Heat losses through various partitions. Temp. dif. 30°

Area in Sq. Ft.	Direct Hot Water Radiation				
	A- A,	B-B,	C	D-D,	
60	6	4	4	3	
80	8	6	5	3	
100	10	7	6	4	
120	12	9	7	5	
140	14	10	8	6	
160	16	12	10	7	
180	18	13	12	8	
200	20	15	13	9	
220	22	16	14	10	
280	24	18	15	11	
260	26	19	17	12	
280	28	21	18	13	

Wood and Hollow tile partitions

A- Plaster 1 side for wood
B- do 2 do do do
C - do 2 do do Hollow tile
B. - 8" Brick Plaster 2 Sides
D. - Expandedmetal, plaster 2 sides, asbestos Fill,
A, - Expanded metal plaster 2 sides air space
D - Double hollow tile, air space and plaster both sides

RADIATION COMPUTING.

Heating-Steam-Roof

Radiation to compensate for Heat losses through Various Roofs. temp. dif 70°

Area in Sq.Ft.	Direct steam Radiation						
	A	B	C	D	E-E_1	F-F_1	G
60	7	8	12	11	16	6	24
80	9	10	16	14	21	8	34
100	12	13	20	18	26	10	43
120	14	16	23	21	31	12	52
140	17	18	27	25	36	14	60
160	19	21	31	28	42	16	69
180	21	23	36	32	47	18	77
200	24	26	39	35	52	20	86
220	26	29	43	39	57	22	95
240	29	31	47	42	63	24	103
260	31	34	51	46	69	26	112
280	33	36	55	49	74	28	120

A= 6" Hollow tile-2" Concrete with tar & Gravel.

B= 8" do do do

C= 4" Concrete with cinder fill.

D= 6" do do

E_1= Tile 3/8 to 1" thick

E= Slate on wood framing only

F= Patent roof (Tar, Gravel, paper etc)

F_1= Slate on tight wood sheathing

G= Iron on wood framing only

RADIATION COMPUTING.

Heating-Hot Water-Roof-

Radiation to Compensate for Heat Losses through Various Roofs temp. dif. 70°

Area in Sq. Ft.	Direct Hot Water Radiator						
	A	B	C	D	E-E₁	F-F₁	G
60	12	13	20	17	26	10	43
80	16	17	26	23	35	13	57
100	20	22	32	29	43	16	71
120	23	26	39	35	52	20	86
140	27	30	45	41	60	22	100
160	31	35	52	47	69	26	114
180	35	39	58	53	77	29	129
200	39	43	64	59	86	32	143
220	43	47	71	65	95	35	156
240	47	52	72	71	103	38	170
260	51	55	84	76	112	42	185
280	55	59	90	82	121	45	199

A • 6" Hollow tile • 2" Concrete with tar & Gravel
B • 8" do do do
C • 4" Concrete with cinder fill
D • 6" do do
E_1 • Tile 3/8" to 1" Thick
E • Slate on wood framing only
F • Patent roof (Tar, Gravel, paper etc)
F_1 • Slate on tight wood sheathing
G • Iron on wood framing only

RADIATION COMPUTING.

Heating-Steam-Ceilings

Radiation to compensate for Heat Losses through Various Ceilings temp. dif. 40°

Area in Sq. Ft	Direct Steam Radiation						
	A	B	C	D	E	F	G
60	5	3	3	5	2	4	1
80	6	3	4	6	2	5	1
100	8	4	5	8	2	6	2
120	10	5	6	9	3	8	2
140	11	6	7	11	3	9	2
160	13	7	8	13	4	10	3
180	14	8	9	14	4	12	3
200	16	9	10	16	5	13	3
220	18	10	11	18	5	14	3
240	19	11	12	19	6	15	4
260	21	12	13	21	6	17	5
280	22	13	14	22	7	18	5

A = Top floor ceilings of residences - Plaster, air space, sheathing, paper, shingles. Temp. dif. = 70°. 25% Exposure.

B = Lath and plaster, single floor above

C = do do No floor above

D = Fire proof. Metal lath no floor above

E = do do Floor above

F = Cement or tile no floor above

G = do do Floor above

RADIATION COMPUTING.

Heating-Hot Water-Ceilings

Radiation to compensate for Heat Losses through Ceilings temp. dif 40°.

Area in Sq. Ft.	Direct Hot Water Radiation						
	A	B	C	D.	E.	F.	G.
60	8	4	5	8	2	6	2
80	11	6	7	11	3	8	2
100	14	7	9	13	4	10	3
120	16	8	10	16	5	12	3
140	19	10	12	18	6	14	4
160	22	11	14	20	6	16	5
180	24	12	15	24	7	18	5
200	27	14	17	26	8	20	6
220	30	15	19	29	9	22	6
240	32	17	21	31	10	24	7
260	35	18	22	34	10	26	8
280	38	19	24	37	12	28	8

A · Top floor ceilings of residences · Plaster, air space, sheathing, paper, shingles. Temp dif · 70° 25% Exposure

B · Lath and plaster, single floor above

C · do do No floor above

D · Fire proof. Metal lath, No floor above

E · do do Floor above

F · Cement or tile No Floor above

G · do do Floor above

Heating-Steam-Floors

Radiation to compensate for Heat Losses through Floors. temp. dif. 30°.

Area in Sq. Ft.	Direct Steam Radiation				
	A-A_1-A_2	B-B_1	C	D	E
60	1	1	1	2	2
80	1	1	1	3	2
100	1	1	1	4	3
120	1	2	1	4	3
140	2	2	1	5	4
160	2	2	1	6	5
180	2	2	2	7	5
200	2	3	2	7	6
220	2	3	2	8	6
240	3	3	2	9	7
260	3	4	2	9	8
280	3	4	3	10	8

A- Double wood floor no plaster beneath
A_1 = Single do do with do do
A_2 = Cement or tile with wood floor on top
B- Single wood floor no plaster beneath
B_1 = do do do near earth
C = Double wood floor with plaster beneath
D - Cement or tile No wood floor
E = Dirt floor no wood whatever

RADIATION COMPUTING

Heating - Hot Water - Floors

Radiation to compensate for Heat Losses through Floors temp. dif. 30°

Area in Sq. Ft.	Direct Hot Water Radiation				
	$A \cdot A_1 \cdot A_2$	$B \cdot B_1$	C	D	E
60	1	1	1	4	3
80	1	2	1	5	4
100	2	2	1	6	5
120	2	2	2	8	6
140	2	3	2	9	6
160	3	3	2	10	7
180	3	4	3	12	8
200	3	4	3	13	9
220	3	4	3	14	10
240	4	5	3	15	11
260	4	5	4	17	12
280	4	6	4	18	13

10

45

A = Double wood floor no plaster beneath

A_1 = Single do do with do do

A_2 - Cement or tile with wood floor on top

B - Single wood floor no plaster beneath

B_1 - do do do near earth

C - Double wood floor with plaster beneath

D - Cement or tile No wood floor

E - Dirt floor no wood whatever

(This completes the Radiation Computing Tables).

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TABLE I. HEAT EMITTED BY DIRECT RADIATION—SINGLE-COLUMN RADIATORS

Steam Temperature at 215 deg. fahr. *Room Temperature at 70 deg fahr.*

	38 In.		32 In		26 In		23 In		20 In	
No. of Sections	Rated Surface sq. ft.	Total B.t.u. per hr	Rated Surface sq ft.	Total B t.u per hr	Rated Surface sq. ft	Total B t.u per hr	Rated Surface sq. ft	Total B t u. per hr	Rated Surface sq ft	Total B t.u. per hr
1	3	1125	2.5	952	2	770	1.66	654	1.5	593
2	6	1849	5.0	1589	4	1293	3.33	1112	3.0	982
3	9	2578	7.5	2217	6	1807	5.00	1555	4.5	1377
4	12	3307	10.0	2845	8	2321	6.66	1997	6.0	1772
5	15	4035	12.5	3471	10	2835	8.33	2440	7.5	2168
6	18	4765	15.0	4098	12	3348	10.00	2882	9.0	2562
7	21	5494	17.5	4725	14	3863	11.66	3324	10.5	2957
8	24	6223	20.0	5354	16	4377	13.33	3767	12.0	3353
9	27	6950	22.5	5982	18	4891	15.00	4209	13.5	3748
10	30	7680	25.0	6610	20	5404	16.66	4652	15.0	4143
11	33	8408	27.5	7236	22	5918	18.33	5095	16.5	4538
12	36	9137	30.0	7863	24	6432	20.00	5538	18.0	4932
13	39	9867	32.5	8489	26	6947	21.66	5980	19.5	5327
14	42	10594	35.0	9117	28	7459	23.33	6422	21.0	5723
15	45	11322	37.5	9744	30	7974	25.00	6865	22.5	6118
16	48	12053	40.0	10372	32	8489	26.66	7309	24.0	6514
17	51	12781	42.5	10999	34	9000	28.33	7752	25.5	6908
18	54	13511	45.0	11624	36	9515	30.00	8193	27.0	7304
19	57	14239	47.5	12250	38	10028	31.66	8635	28.5	7698
20	60	14964	50.0	12875	40	10544	33.33	9080	30.0	8094

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TABLE 2. HEAT EMITTED BY DIRECT RADIATION—TWO-COLUMN RADIATORS

Steam Temperature at 215 deg. fahr. *Room Temperature at 70 deg. fahr.*

	45 In.		38 In.		32 In.		26 In.		23 In.		20 In.	
No. of Sections	Rated Surface sq. ft.	Total B.t.u. per hr.	Rated Surface sq. ft.	Total B.t.u. per hr.	Rated Surface sq. ft.	Total B.t.u. per hr.	Rated Surface sq. ft.	Total B.t.u. per hr.	Rated Surface sq. ft.	Total B.t.u. per hr.	Rated Surface sq. ft.	Total B.t.u. per hr.
1	5	1892	4	1586	3.33	1237	2.66	1100	2.33	967	2	823
2	10	2975	8	2475	6.66	2121	5.33	1736	4.66	1520	4	1313
3	15	4059	12	3373	10.00	2903	8.00	2373	7.00	2093	6	1810
4	20	5142	16	4272	13.33	3675	10.66	3010	9.33	2666	8	2304
5	25	6225	20	5172	16.66	4452	13.33	3652	11.66	3239	10	2798
6	30	7308	24	6072	20.00	5220	16.00	4289	14.00	3809	12	3292
7	35	8390	28	6972	23.33	5992	18.66	4920	16.33	4376	14	3786
8	40	9476	32	7869	26.66	6768	21.33	5560	18.66	4943	16	4279
9	45	10562	36	8766	30.00	7539	24.00	6197	21.00	5510	18	4772
10	50	11645	40	9668	33.33	8323	26.66	6832	23.33	6081	20	5264
11	55	12727	44	10567	36.66	9112	29.33	7471	25.66	6648	22	5753
12	60	13810	48	11467	40.00	9888	32.00	8109	28.00	7213	24	6245
13	65	14892	52	12367	43.33	10662	34.66	8746	30.33	7780	26	6738
14	70	15974	56	13266	46.66	11436	37.33	9383	32.66	8346	28	7232
15	75	17058	60	14164	50.00	12210	40.00	10020	35.00	8897	30	7728
16	80	18143	64	15062	53.33	12987	42.66	10662	37.33	9464	32	8221
17	85	19227	68	15960	56.66	13764	45.33	11299	39.66	10032	34	8714
18	90	20311	72	16859	60.00	14538	48.00	11933	42.00	10601	36	9209
19	95	21394	76	17758	63.33	15310	50.66	12570	44.33	11167	38	9703
20	100	22478	80	18656	66.66	16080	53.33	13211	46.66	11736	40	10196

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TABLE 3. HEAT·EMITTED BY DIRECT RADIATION--THREE-COLUMN RADIATORS

Steam Temperature at 215 deg fahr — *Room Temperature at 70 deg fahr*

No of Sections	45 In		38 In		32 In		26 In		23 In		20 In	
	Rated Surface sq. ft	Total B t u per hr.	Rated Surface sq. ft.	Total B t u. per hr	Rated Surface sq. ft.	Total B.t.u. per hr	Rated Surface sq. ft	Total B t.u per hr	Rated Surface sq. ft.	Total B.t.u. per hr	Rated Surface sq ft.	Total B.t.u. per hr.
1	6	2241	5	1898	4.5	1665	3.75	1372	3	1138	2.25	878
2	12	3480	10	2955	9.0	2635	7 50	2195	6	1816	4.50	1430
3	18	4720	15	4013	13.5	3605	11.25	3017	9	2496	6.75	1961
4	24	5959	20	5070	18.0	4674	15.00	3840	12	3174	9.00	2491
5	30	7197	25	6128	22.5	5544	18.75	4661	15	3854	11.25	3020
6	36	8435	30	7185	27.0	6512	22 50	5485	18	4532	13.50	3553
7	42	9677	35	8243	31.5	7481	26.25	6308	21	5211	15.75	4084
8	48	10915	40	9300	36.0	8453	30.00	7128	24	5890	18.00	4615
9	54	12155	45	10358	40.5	9420	33.75	7952	27	6569	20.25	5146
10	60	13392	50	11415	45.0	10391	37.50	8775	30	7248	22.50	5679
11	66	14632	55	12473	49.5	11360	41.25	9595	33	7927	24.75	6210
12	72	15872	60	13530	54.0	12328	45.00	10418	36	8608	27.00	6742
13	78	17113	65	14587	58.5	13297	48.75	11242	39	9286	29.25	7273
14	84	18354	70	15645	63.0	14270	52.50	12065	42	9962	31.50	7803
15	90	19593	75	16703	67 5	15242	56.25	12889	45	10643	33.75	8333
16	96	20832	80	17760	72.0	16207	60.00	13710	48	11323	36.00	8863
17	102	22068	85	18817	76.5	17174	63.75	14531	51	12000	38.25	9398
18	108	23306	90	19872	81.0	18144	67.50	15353	54	12679	40.50	9931
19	114	24544	95	20936	85.5	19118	71.25	16174	57	13361	42.75	10464
20	120	25776	100	21990	90.0	20088	75.00	16995	60	14040	45.00	10989

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TABLE 4. HEAT EMITTED BY DIRECT RADIATION—FOUR-COLUMN RADIATORS

Steam Temperature at 215 deg. fahr *Room Temperature at 70 deg. fahr.*

	45 In		38 In		32 In.		26 In		23 In.		20 In.	
No. of Sections	Rated Surface sq. ft	Total B.t.u. per hr	Rated Surface sq. ft.	Total B.t.u. per hr	Rated Surface sq. ft.	Total B.t.u per hr	Rated Surface sq. ft.	Total B.t.u. per hr	Rated Surface sq. ft.	Total B.t.u. per hr	Rated Surface sq. ft.	Total B.t.u. per hr.
1	10	3092	8	2567	6.5	2166	5	1730	4	1430	3	1125
2	20	5000	16	4150	13.0	3513	10	2808	8	2320	6	1823
3	30	6909	24	5730	19.5	4859	15	3887	12	3211	9	2522
4	40	8816	32	7315	26.0	6205	20	4964	16	4101	12	3218
5	50	10725	40	8900	32.5	7550	25	6043	20	4992	15	3917
6	60	12636	48	10483	39.0	8896	30	7122	24	5882	18	4615
7	70	14539	56	12069	45.5	10242	35	8198	28	6773	21	5313
8	80	16445	64	13651	52.0	11588	40	9276	32	7664	24	6011
9	90	18360	72	15235	58.5	12934	45	10355	36	8554	27	6710
10	100	20270	80	16816	65.0	14281	50	11435	40	9444	30	7404
11	110	22176	88	18396	71.5	15627	55	12513	44	10336	33	8103
12	120	24084	96	19978	78.0	16973	60	13592	48	11227	36	8802
13	130	25987	104	21570	84.5	18320	65	14671	52	12118	39	9501
14	140	27902	112	23150	91.0	19665	70	15750	56	13009	42	10198
15	150	29805	120	24732	97.5	21011	75	16827	60	13896	45	10895
16	160	31712	128	26330	104.0	22357	80	17904	64	14784	48	11592
17	170	33626	136	27921	110.5	23702	85	18981	68	15675	51	12291
18	180	35537	144	29506	117.0	25049	90	19061	72	16567	54	12987
19	190	37430	152	31084	123.5	26395	95	21140	76	17459	57	13685
20	200	39340	160	32652	130.0	27742	100	22220	80	18352	60	14382

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TABLE 5. HEAT EMITTED BY DIRECT RADIATION—HOSPITAL RADIATORS—TWO COLUMNS

Steam Temperature at 215 deg. fahr. *Room Temperature at 70 deg. fahr.*

	45 In.		38 In.		32 In.		26 In.		23 In.		20 In.	
No. of Sections	Rated Surface sq. ft.	Total B.t.u. per hr	Rated Surface sq. ft.	Total B.t.u. per hr	Rated Surface sq. ft.	Total B.t.u. per hr.	Rated Surface sq. ft.	Total B.t.u. per hr.	Rated Surface sq. ft.	Total B.t.u. per hr.	Rated Surface sq. ft.	Total B.t.u. per hr.
1	5	1966	4	1628	3.33	1391	2.66	1128	2.33	998	2	861
2	10	3118	8	2597	6.66	2219	5.33	1813	4.66	1606	4	1391
3	15	4271	12	3558	10.00	3051	8.00	2498	7.00	2213	6	1921
4	20	5424	16	4520	13.33	3878	10.66	3179	9.33	2821	8	2448
5	25	6575	20	5480	16.66	4710	13.33	3864	11.66	3429	10	2979
6	30	7725	24	6439	20.00	5538	16.00	4547	14.00	4036	12	3509
7	35	8875	28	7400	23.33	6369	18.66	5228	16.33	4644	14	4038
8	40	10028	32	8362	26.66	7196	21.33	5913	18.66	5251	16	4568
9	45	11183	36	9324	30.00	8025	24.00	6600	21.00	5859	18	5099
10	50	12335	40	10284	33.33	8856	26.66	7282	23.33	6468	20	5626
11	55	13487	44	11242	36.66	9684	29.33	7966	25.66	7074	22	6156
12	60	14640	48	12206	40.00	10512	32.00	8650	28.00	7683	24	6686
13	65	15789	52	13166	43.33	11341	34.66	9330	30.33	8290	26	7215
14	70	16940	56	14129	46.66	12169	37.33	10016	32.66	8899	28	7744
15	75	18090	60	15084	50.00	13000	40.00	10696	35.00	9506	30	8274
16	80	19248	64	16045	53.33	13829	42.66	11378	37.33	10114	32	8803
17	85	20400	68	17007	56.66	14658	45.33	12062	39.66	10722	34	9333
18	90	21551	72	17971	60.00	15486	48.00	12744	42.00	11327	36	9864
19	95	22705	76	18932	63.33	16314	50.66	13425	44.33	11935	38	10393
20	100	23850	80	19888	66.66	17142	53.33	14111	46.66	12544	40	10920

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TABLE 6. HEAT EMITTED BY DIRECT RADIATION—WALL RADIATORS

Steam Temperature at 215 deg. fahr. *Room Temperature at 70 deg fahr*

	9B—29 in		7B—22 in		5A—13 in	
No. of Sections	Rated Surface sq. ft	Total B.t.u. per hr.	Rated Surface sq ft	Total B.t.u per hr	Rated Surface sq ft	Total B t u per hr
1	9	2853	7	2234	5	1658
2	18	5456	14	4281	10	3208
3	27	8059	21	6327	15	4758
4	36	10663	28	8372	20	6308
5	45	13266	35	10420	25	7860
6	54	15869	42	12466	30	9408
7	63	18472	49	14513	35	10959
8	72	21074	56	16559	40	12508
9	81	23676	63	18604	45	14063
10	90	26280	70	20650	50	15610
11	99	28888	77	22700	55	17160
12	108	31493	84	24746	60	18708
13	117	34094	91	26790	65	20261
14	126	36696	98	28832	70	21812
15	135	39299	105	30881	75	23363
16	144	41904	112	32928	80	24913
17	153	44508	119	34974	85	26461
18	162	47110	126	37019	90	28008
19	171	49715	133	39062	95	29560
20	180	52322	140	41118	100	31110

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TABLE 7 HEAT EMITTED BY DIRECT RADIATION—WINDOW RADIATORS

Steam Temperature at 215 deg. fahr. *Room Temperature at 70 deg fahr.*

	20 In.		16 In		13 in.	
No. of Sections	Rated Surface sq. ft	Total B.t.u. per hr.	Rated Surface sq ft	Total B.t.u per hr	Rated Surface sq. ft	Total B.t.u per hr
1	5	1708	3.75	1332	3	1082
2	10	2761	7.50	2156	6	1762
3	15	3816	11.25	2979	9	2441
4	20	4872	15.00	3803	12	3119
5	25	5930	18.75	4626	15	3798
6	30	6987	22.50	5450	18	4477
7	35	8043	26.25	6274	21	5156
8	40	9098	30.00	7098	24	5836
9	45	10152	33.75	7921	27	6516
10	50	11210	37.50	8745	30	7194
11	55	12265	41.25	9570	33	7871
12	60	13320	45.00	10395	36	8550
13	65	14378	48.75	11217	39	9227
14	70	15435	52.50	12038	42	9908
15	75	16490	56.25	12864	45	10589
16	80	17544	60.00	13686	48	11266
17	85	18598	63.75	14510	51	11944
18	90	19656	67.50	15336	54	12625
19	95	20710	71.25	16160	57	13304
20	100	21770	75.00	16988	60	13986

RADIATION COMPUTING—Heat Emitted by Window Radiators No. 13-SS

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TABLE 8. HEAT EMITTED BY DIRECT RADIATION—CONVERSION FACTORS

Pressure		Temp. of Steam in deg. fahr.	Temperature of Room in deg. fahr.					
Vacuum In. Hg.	Lb. Absolute		80 deg. fahr.	75 deg fahr.	70 deg fahr.	65 deg fahr.	60 deg. fahr.	50 deg. fahr.
23.4	3.71	150	2.188	2.053	1.934	1.828	1.733	1.572
19.7	4.75	160	1.898	1.795	1.701	1.621	1.546	1.412
15.3	5.99	170	1.660	1.590	1.517	1.451	1.391	1.285
12.3	7.51.	180	1.488	1.425	1.364	1.311	1.261	1.175
8.7	9.33	190	1.339	1.287	1.239	1.195	1.155	1.081
6.5	11.52	200	1.215	1.172	1.135	1.095	1.060	0.999
Lb. Gage								
1	15.7	215	1.064	1.029	1.000	0.971	0.943	0.894
2	16.8	219	1.030	1.000	0.970	0.941	0.915	0.870
3	17.8	222	1.004	0.976	0.947	0.921	0.897	0.851
4	18.9	225	0.982	0.954	0.929	0.902	0.878	0.835
5	19.6	227	0.964	0.936	0.909	0.887	0.864	0.822
6	20.8	230	0.943	0.917	0.892	0.869	0.847	0.806
8	22.8	235	0.907	0.883	0.860	0.839	0.818	0.781
10	24.9	240	0.875	0.853	0.831	0.810	0.791	0.756

These conversion factors multiplied by the heat loss from any radiator, operating under the indicated conditions, give the hea loss by the same radiator operating at 215 deg. fahr. in a room at 70 deg fahr

BOILERS

Boiler Horse-Power and Ratios.

A flue boiler will evaporate 2 lbs. of water per hour per square foot of heating surface. Now, as the evaporation of 30 lbs. of water per hour into steam of 70 lbs. gauge pressure, when feed water has a temperature of 100° F., constitutes a horse power, then each 15 sq. ft. of heating surface in this type of boiler, with good coal and good draft, will generate a horse-power.

Tubular and water-tube boilers can be made to furnish a horse-power for each 12 sq. ft. of heating surface. Locomotive boilers will develop 1 horse-power for each 8 sq. ft. of heating surface. Under average conditions, with feed water at 100° F., and steam at 70 lbs. gauge pressure, and 3,000 lbs. of water evaporated in one hour in any boiler above mentioned, then $3{,}000 \div 30 = 100$ horse-power developed by that boiler. In actual practice, however, the conditions must be reduced to the standard given, as follows:

Rule—Multiply the total heat of steam at pressure carried (minus temperature of feed water) by the pounds of water evaporated per hour and divide by 33,000 B. T. U.. The quotient will be the pounds of water evaporated with feed water at 100° F., and a steam pressure of 70 lbs.

Problem—The stem pressure being 90 lbs. and feed water 210° F., and 3,400 lbs. of water being evaporated per hour, what is the horse-power? Referring to steam table we find that 90 lbs. gauge pressure (or 105 lbs. absolute pressure) contains 1,182° above 32 or $1{,}182 + 32 = 1{,}214$. Then $1{,}214 - 210 = 1{,}004°$, and $1{,}004 \times 3{,}400 = 3{,}413{,}600$, This $\div 33{,}000 = 102$ H. P. which would have been evaporated under standard conditions with the same amount of heat.

The horse-power of boilers is best defined by the heating surface of a boiler and is different according to its construction. A tubular boiler will give one horse-power to every 15 sq. ft. of heating surface; a flue boiler every 12 sq. ft.; with a cylinder boiler 10 sq. ft. gives one horse-power. There is no standard law governing the horse-power of steam boilers, but this rule is adopted by most experts as a fair rating.

One cubic foot of water evaporated per hour = 2 nominal horse-power.

7½ lbs. of coal consumed per hour will evaporate about 1 cu. ft. of water = 2 horse-power.

1 sq. ft. of grate will consume on average 12 lbs. of coal per hour = 3.2 H. P.

BOILERS.

Engine Horse-Power.

All calculations to find the horse-power of an engine are necessarily only approximate, as they are modified more or less by the factors of friction in the moving parts, condensation, quality of lubricants, amount of load, etc.

The unit of power is the horse-power; and was first calculated by Watt, the prince of inventors in steam enginery; after numerous experiments. Watt estimated the power of a good, average draft horse to be that which could lift 33,000 lbs. one foot high in a minute, 550 lbs. in one second, or 1,980,000 lbs. in an hour. Hence, we have the horse-power factor, 33,000 lbs.

RULE TO FIND HORSE-POWER OF AN ENGINE.

Area of piston in inches multiplied by pressure per square inch, multiplied by speed of piston in feet per minute, and that product divided by 33,000

$$H. P. = \frac{P L A N}{33{,}000}$$

P = Pounds pressure per square inch.
L = Length of stroke in feet.
A = Area of piston in square inches.
N = Number revolutions per minute.

The pressure per square inch should be the mean pressure throughout the stroke exerted on the piston, which can be found by attaching an indicator to the engine. The result will be what engineers term indicated horse-power.

For the net effective horse-power, deduct from the above about one-quarter for friction of the working parts.

When the indicator is not used, and in the calculation the boiler pressure is substituted for the mean effective pressure, deduct from the result obtained from 40% to 60% for loss by condensation and friction of steam in pipes and passages, decrease of pressure in cylinder due to expansion, back pressure of exhaust, and friction of the working parts.

For engines from 20 to 60 H. P., and average of 50% may be deducted; for smaller engines more.

The mean pressure in the cylinder when cutting off at

¼ stroke equals boiler pressure multiplied by 0.597
⅓ stroke equals boiler pressure multiplied by .670
⅜ stroke equals boiler pressure multiplied by .743
½ stroke equals boiler pressure multiplied by .847
⅝ stroke equals boiler pressure multiplied by .919
⅔ stroke equals boiler pressure multiplied by .937
¾ stroke equals boiler pressure multiplied by .966
⅞ stroke equals boiler pressure multiplied by .992

BOILER CAPACITIES FOR DIRECT RADIATION.

To meet the condition where several types of radiation are installed on the same heating system, together with other kinds of heating load, and at the same time provide for the fact that boiler ratings represent various standards of boiler testing, a chart has been devised by the Chicago Master Steam Fitters' Association, which facilitates the approximate estimating of required minimum boiler capacity.

For computing minimum size of boiler required for the average building, based upon approved ratings specified in the manufacturers' catalogs, the first step is to reduce all radiation to the equivalent amount of cast-iron column radiation. Having totalled this equivalent radiation, find the percent to be added as a factor of safety when building is to be heated from 10° to 70° F., by referring to the chart, reading horizontally according to the key number of the desired type of boiler and vertically according to the total equivalent radiation. Having added this percentage for safety, add the computed equivalent of other heating load and the total gives minimum rated capacity of boiler required.

EXAMPLE

Find the size of steel down-draft, brick-set boiler required for the following installation (Key No. 7 on chart):

(1) 500 sq. ft. of direct cast-iron column radiation in rooms to be heated from 10° to 70° F.
(2) 500 sq. ft. of direct cast-iron column radiation in rooms to be heated from—10° to 50° F.
(3) 500 sq. ft. of cast-iron wall-type radiation, or wall pipe coils (being the equivalent of 625 sq. ft. of cast-iron column radiation) in rooms to be heated from—10° to 50° F.
(4) 500 sq. ft. of indirect radiation
(5) 500 sq. ft. of direct-indirect radiation.
(6) 250 gal. hot water tank. Water to be heated with steam coils.
(7) 500 sq. ft. of cast-iron fan blast radiation, regular sections, 5-in. centers, 1000 ft. velocity, air taken from out of doors—10° to F. T.
80° F. Radiation three stacks deep.

METHOD

(1)	500 sq. ft.	500
(2)	500 sq. ft. plus 13%	565
(3)	500 sq. ft. plus 25% plus 13%	707
(4)	500 sq. ft. plus 50%	750
(5)	500 sq. ft. plus 25%	625
(6)	250 gal. x 2	500
		3647
	Add factor of safety 37.8%	1378
		5025
	(See Key No. 7 and 3700 load, on chart)	
(7)	500 x 1.92 x 4 plus 15%.	4416
	Minimum rated capacity of boiler	9441

(*Concluded on Data Sheet No. 49-C*)

BOILER CAPACITIES FOR DIRECT RADIATION

(Concluded from Data Sheet No. 49-B)

RADIATION LOAD

Key		1000	1100	1200	1300	1400	1600	1600	1700	1800	1900	2000	2100	2200	2300	2400	2600	2600	2700	2800	2900	3000	3100	3200	3300	3400	3500	3600	3700	3800	3900
1	FACTOR OF SAFETY OVER RADIATION LOAD	92	92	92	92	92	92	92	92	92	92	92	92	92	92	92	92	92	92	92	92	92	92	92	.92	92	92	92	92	.92	92
2		100	995	.99	985	983	98	975	97	965	963	958	953	95	945	94	938	933	928	925	92	915	913	.908	903	.90	895	89	887	883	878
3		68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	.68	.68	68	68	68	68	68
4		80	798	796	794	79	785	783	779	.775	773	.77	768	763	76	758	753	75	748	745	743	738	735	733	729	725	723	.72	717	713	71
5		75	745	74	735	73	725	72	715	71	705	70	695	69	685	68	675	67	665	66	655	65	645	64	635	.63	625	62	.615	61	605
6		50	498	495	493	49	488	485	483	48	478	475	473	47	468	465	463	46	458	453	45	448	453	44	438	435	433	.43	428	425	423
7		45	448	445	443	44	438	435	433	43	428	425	423	42	418	415	413	41	408	403	40	398	393	39	388	385	383	38	378	375	373
8		40	398	397	395	394	393	391	39	388	387	385	384	383	381	38	378	377	375	374	373	37	368	367	365	364	363	361	.36	358	357
9		35	348	347	345	344	343	341	34	338	337	335	334	333	331	33	328	327	325	324	323	32	318	317	315	314	313	311	31	308	307
10		30	.298	297	.295	294	293	291	29	288	287	285	284	283	281	28	278	277	275	274	273	27	268	267	265	264	263	261	26	258	257

RADIATION LOAD

Key		4000	4100	4200	4300	4400	4500	4600	4700	4800	4900	5000	5100	5200	5300	5400	5500	5600	5700	5800	5900	6000	6100	6200	6300	6400	6500	6600	6700	6800	6900
1	FACTOR OF SAFETY OVER RADIATION LOAD	92	92	92	92	92	.92	92	92	92	92	92	92	92	92	92	92	92	92	92	92	92	92	92	92	92	92	92	92	92	92
2		875	87	865	863	858	.855	85	845	84	837	832	828	825	.82	815	81	808	803	798	795	79	787	783	778	773	77	.765	76	758	753
3		68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	.68	68	68	68	68	68
4		707	703	70	698	694	691	688	685	682	678	675	673	669	665	663	659	657	655	65	648	643	64	638	634	63	628	625	623	619	615
5		60	598	596	595	593	592	59	588	587	586	585	583	581	58	579	577	575	574	573	571	57	568	566	565	564	562	56	559	558	555
6		42	418	415	413	41	408	405	403	40	398	395	393	39	388	385	383	38	378	375	373	37	368	365	363	36	358	355	353	.35	348
7		37	368	365	363	35	358	355	353	35	348	345	343	34	338	335	333	33	328	325	323	32	318	315	313	31	308	305	303	30	298
8		355	354	353	351	35	.348	347	345	343	341	34	338	337	335	334	333	331	33	328	327	325	324	323	321	32	318	317	315	314	313
9		305	304	303	301	30	298	297	295	293	291	29	288	287	285	284	283	.281	28	278	277	275	274	.273	271	27	268	.267	265	.264	263
10		.255	254	253	251	25	248	247	245	243	241	24	239	237	235	234	233	231	23	228	227	225	224	223	221	22	218	217	215	214	213

NOTE—No boiler to be installed having grate longer than 72"

RADIATION LOAD

Key		7000	7100	7200	7300	7400	7500	7600	7700	7800	7900	8000	8100	8200	8300	8400	8500	8600	8700	8800	8900	9000	9200	9400	9600	9800	10000	10200	10400	10600	10800
1	FACTOR OF SAFETY OVER RADIATION LOAD	92	.92	92	92	92	92	92	92	92	92	.92	92	92	92	92	92	92	92	92	92	92	92	92	92	92	92	92	92	92	92
2		75	745	74	735	73	728	723	72	715	71	705	701	699	693	69	685	68	675	673	669	665	66	655	65	647	643	64	638	636	635
3		68	68	68	68	68	68	68	68	68	68	68	.68	68	68	68	68	68	68	68	68	68	68	.68	68	68	68	68	68	68	68
4		613	608	606	603	60	596	593	59	586	583	58	578	574	.57	.568	563	561	558	555	551	548	545	542	539	536	533	531	53	528	526
5		554	552	55	549	548	547	546	545	543	541	54	538	536	535	533	531	53	529	527	525	524	523	52	519	517	516	515	515	514	513
6		345	343	34	338	335	333	33	328	325	323	32	318	315	.313	31	305	30	298	295	293	29	289	288	286	285	278	276	275	274	273
7		295	293	29	288	285	283	28	278	275	273	.27	.268	.265	263	26	255	25	248	245	243	24	239	238	236	235	228	226	225	224	223
8		306	304	303	301	299	298	296	295	293	292	.29	.289	287	285	.283	282	28	279	277	275	274	273	271	27	269	266	265	264	264	263
9		256	254	253	.251	249	248	246	245	243	242	.24	.239	.237	235	233	232	23	229	227	225	224	223	221	22	219	216	215	214	214	213
10		206	204	203	201	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20

RADIATION LOAD

Key		11000	11200	11400	11600	11800	12000	12200	12400	12600	12800	13000	13200	13400	13600	13800	14000	& Over
1	FACTOR OF SAFETY OVER RADIATION LOAD	.92	92	92	92	92	92	92	92	92	92	92	92	92	92	92	92	92
2		633	63	628	625	623	621	62	618	615	613	612	608	606	605	603	60	60
3		68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68
4		525	523	522	52	518	516	515	513	512	51	508	507	506	505	503	50	.50
5		512	512	511	51	509	508	507	506	505	505	504	503	503	502	501	50	50
6		27	269	268	267	266	265	264	261	26	259	258	256	255	253	251	25	25
7		22	219	218	217	216	215	214	211	21	209	207	206	205	203	201	20	20
8		262	261	26	26	259	258	257	256	256	255	255	254	253	252	251	25	25
9		212	211	21	21	209	208	207	206	206	205	205	204	203	202	201	20	20
10		20	20	.20	20	20	20	20	20	20	20	20	20	20	20	20	20	20

NOTE—No boiler to be installed having grate longer than 72"

The key numbers given on the chart refer to boilers of the following types:

KEY

1—American Radiator Co., type "C"
2—Bryant Heater & Mfg. Co., gas boiler
2—Cast-Iron up-draft
3—American Radiator Co., type "A"
4—Cast-Iron Smokeless (approved type)
5—Cast-Iron, magazine type
6—Oil City portable
6—Pacific portable
6—Herbert down-draft
7—Kewanee smokeless
8—Herbert up-draft
9—Kewanee up-draft
10—Kewanee up-draft with approved arch.

CHIMNEYS

Note:—The following tables and memoranda on chimneys are selected from a discussion of the subject by Harold L. Alt, which appeared in THE HEATING AND VENTILATING MAGAZINE *for March and April,* 1917, *and to which the reader is referred for more complete information.*

The most common error made in regard to chimneys is that of not distinguishing between the size (which governs the volume of smoke they can handle) and the height (which determines the intensity of the draft). A chimney may be *high* enough yet with an *area* too small to do the work required. On the other hand it may be *large* enough but too *low* to produce a *draft* of the strength required to pull the air through the fire and up the chimney at a sufficiently rapid rate. Eeither fault, or a combination of both, will result in unsatisfactory service and will require remedying.

Heated air expands and occupies a greater volume than the outer air of a lesser temperature, so if a cubic foot of air outside the chimney weighs 0.07 lbs. and a cubic foot of the chimney gases at their higher temperature weighs only 0.04 lbs. then every vertical foot of air in the chimney means an unbalanced pressure of 0.07 — 0.04, or 0.03 lbs. per square foot at the base. This unbalanced pressure has a tendency to equalize by the rising of the lighter gases but since their place is taken by more heated gases coming directly from the fire the temperature, of course, never does equalize and the action continues its operation as long as the fire is kept burning.

From this basic principle all chimney action is governed and many chimney failings can be explained. For instance, the draft of a chimney is never as good in summer as in winter because the outside air is colder in the winter, the expansion of the chimney gases at the same temperature is, therefore, relatively greater and the intensity of the chimney draft is consequently increased.

Chimneys have to overcome their own losses, these losses consisting of the friction of the gases rubbing against the sides in their upward passage. For this reason a *circular-shaped flue* is most desirable, the next, square, and after that oblong with the *long* side *not more* than *double* the length of the *short* side. In flues where it is necessary to exceed this proportion *two* separate flues of more desirable shape can sometimes be used with advantage.

The most efficient chimney, as far as draft is concerned, is one built perfectly straight from the bottom up, round (or nearly round) in the shape of the interior flue, and lined with tile, or with the interior surface made as smooth as possible by other means. There is no advantage in tapering the inside of a chimney to a smaller size toward the top—this only retards the flow of the gases.

A square chimney can hardly be figured as having its full area effective, a *deduction* of 10% to 15% being necessary on account of the spiral movement of the gases leaving the corners dead and inactive. With an oblong shape the effect is worse, a deduction of 25% being none too much. The use of tile flues will not only aid this slightly, owing to their rounded corners, but will also safeguard much of the fire risk otherwise due to mortar falling out between the bricks as time passes and leaving openings through which a spark might pass. As the tile serves to retain the gases and smoke it also prevents leakage which can spoil a chimney action at any time, no matter how perfectly the flue may otherwise be built.

RESIDENCE CHIMNEYS

The ordinary residence usually employs a chimney between 25 and 60 ft. high, the area being proportional to the size of the house and it is interesting to note that it is possible to burn No. 1 buckwheat coal with a chimney 55 ft. high, if the fire bed is not made too thick. Down-draft boilers should have chimneys at least 60 ft. high to operate successfully.

Having a chimney built upon desirable lines, as far as draft is concerned, it may, of course, still be too small, and in this connection it might be said that no flue should be made *less* than 8 in. diameter or 8 in. × 8 in. square. Under ordinary conditions, with steam, furnace, or water heating, the following sizes of flues given in the table will be found to give satisfaction in residences whose cubic footage does not exceed the amounts shown:

SIZES OF FLUES FOR RESIDENCES.

Cubic Contents of Building. Cubic Feet.	*Round.* Inches Diam.	*Square.* Inches.	*Oblong.* Inches.
20,000	8	8 × 8	6 × 10
40,000	9	9 × 9	8 × 12
60,000	10	10 × 10	8 × 14
110,000	12	12 × 12	10 × 18
120,000	14	14 × 14	12 × 18
130,000	16	16 × 16	12 × 18
150,000	18	18 × 18	14 × 20

When flue tile is used the interior dimensions are not in even figures, the exact dimensions of commercial sizes being given in the table below:

COMMERCIAL SIZES AND AREAS OF FLUE TILE.

Square or Oblong Outside Dimensions, Inches.	Circular Inside Dimensions, Inches	Area Sq. in.
..	8	50
8½ × 8½	..	52
..	9	64
..	10	78
8½ × 13½	..	80
..	11	95
..	12	113
13 × 13	..	126
..	13	133
13 × 18	14	154
..	..	169
..	15	177
..	16	201
..	17	227
18 × 18	..	240

RESIDENCE CHIMNEYS

When square or rectangular chimneys are designed for fire places which burn wood or bituminous coal they are usually made with an area of 10% to 12% of the fire place opening, while with round flues the area may be reduced to 8%. For anthracite coal the rectangular or square flue may be reduced to 8% and the round flue to 6%. Ordinary stoves are readily served with an 8 in. × 8 in. flue, provided no other connections are made to it.

All chimney walls should be 8 in. thick to avoid danger of fire from sparks working through the joints, and the building laws in some cases demand not only 8 in. thick walls but tile linings as well.

The *height* of residence chimneys, as before mentioned, is usually of small moment, since the use of larger sizes of anthracie coal is common under such conditions. The draft, however, ought to approximate in inches of water the various values given in the table below after being in use twenty-four hours and with all the inlets suddenly closed.

DRAFT IN CHIMNEYS FOR RESIDENCES.

	Temperature of Outgoing Gases, Deg. F.		
Height in Feet.	200	250	300
	Inches	of	Water
60	0.27	0.32	0.35
55	0.25	0.29	0.32
50	0.23	0.26	0.29
45	0.21	0.23	0.26
40	0.18	0.21	0.23
35	0.16	0.19	0.20
30	0.14	0.16	0.17
25	0.12	0.14	0.14
20	0.09	0.11	0.12

The figures given are about 90% efficiency of the theoretical draft which an absolutely tight chimney would show and a properly constructed chimney should approximate these figures.

CHIMNEYS.

Coal and Air per Boiler Horse-Power.

The first factor to develop in determining the proper diameter and height of the chimney required is the maximum number of pounds of coal burned per hour and the number of pounds of air required. If the actual boiler horsepower to be developed at the maximum can be computed or assumed the number of pounds of coal for various efficiences may be read directly from the following table:

REQUIRED POUNDS OF COAL AND AIR FOR HORSEPOWERS AT VARIOUS EFFICIENCIES

Total Lbs. of Coal	POUNDS OF COAL PER BOILER H. P. DEVELOPED							Lbs. of Air per Sec.
	4	4½	5	5½	6	6½	7	
	HORE POWER DEVELOPED							
50	12	11	10	9	8	8	7	0.25
100	25	22	20	18	16	15	14	0.5
150	17	33	30	27	25	23	21	0.75
200	50	44	40	36	33	31	29	1.0
300	75	67	60	55	50	46	43	1.5
500	125	111	100	91	83	77	71	2.5
750	187	167	150	136	125	115	107	3.7
1,000	250	222	200	182	167	154	143	5.0
1,500	375	333	300	273	250	231	214	7.5
2,000	500	444	400	363	333	308	286	10.0
2,500	625	555	500	455	416	385	357	12.5
3,000	750	667	600	545	500	461	429	15.0
4,000	1,000	889	800	727	667	615	571	20.0
5,000	1,250	1,111	1,000	909	833	769	714	25.
7,500	1,875	1,667	1,500	1,364	1,250	1,154	1,071	38.
10,000	2,500	2,222	2,000	1,818	1,667	1,538	1,429	50.
15,000	3,750	3,333	3,000	2,727	2,500	2,308	2,143	75.
20,000	5,000	4,444	4,000	3,636	3,333	3,077	2,857	100.
30,000	7,500	6,667	6,000	5,454	5,000	4,615	4 286	150.
40,000	10,000	8,889	8,000	7,273	6,666	6,154	5,714	200.
50,000	12,500	11,111	10,000	9,091	8,333	7,692	7,143	250.
75,000	18,750	16,667	15,000	13,645	12,500	11,538	10,714	375.
100,000	25,000	22,222	20,000	18,181	16,667	15,384	14,286	500.
125,000	31,250	27,778	25,000	22,745	20,833	19,230	17,857	625.
150,000	37,500	33,333	30,000	27,273	25,000	23,076	21,428	750.
200,000	50,000	44,444	40,000	36,363	33,333	30,768	28,576	1,000.
300,000	75,000	66,667	60,000	54,545	50,000	46,154	42,857	1,500.
400,000	100,000	88,887	80,000	72,727	66,667	61,536	57,143	2,000.
500,000		111,111	100,000	90,909	83,333	76,923	71,428	2,500.
750,000				136.455	125,000	115,380	107,143	3,750.
1,000,000							142,860	5,000.

N. B.—The above horsepowers are not rated boiler horsepowers, but are actual developed boiler horsepower.

CHIMNEYS

Draft Loss in Fire and Boiler.

The next factor consists of determining the draft loss through the fire, this loss varying according to the number of pounds of coal burned per square foot of grate and the quality of coal used.

Tests show that under average conditions the loss of draft through the fire runs about as follows:

DRAFT LOSS IN FIRE.

(In. of water)

	POUNDS OF COAL PER SQUARE FOOT PER HOUR BURNED ON GRATES								
FUEL	5	10	15	20	25	30	35	40	45
Anthracite									
No. 3 Buck	0.15	0.40	0.75	1.24	..	..	..	..	..
No. 1 Buck	0.10	0.24	0.44	0.68	1.00	..	..	..	..
Pea	0.06	0.16	0.30	0.45	0.65	0.90	1.20	..	..
Bituminous									
Semi bituminous	0.05	0.10	0.18	0.26	0.35	0.45	0.58	0.70	0.78
Penn. Ala. Ill. & Ind.	0.04	0.09	0.15	0.22	0.28	0.38	0.45	0.55	0.60
Slack	0.04	0.07	0.10	0.15	0.20	0.27	0.34	0.40	0.50
Run of Mine	0.04	0.05	0.08	0.10	0.14	0.16	0.20	0.25	0.32
On Chain Grate	0.05	0.12	0.15	0.23	0.31	0.44	0.57	0.75	0.94

For ordinary installations the burning of 5 lbs. of coal per horsepower is usually assumed. The maximum number of pounds of coal which a boiler must consume divided by the grate area in square feet will give the number of pounds of coal burned per square foot of grate.

The draft losses in boilers run about as follows:

Type of Boiler.	Per cent of Nominal Rating Developed		
	100	150	200
	Loss in Inches of Water		
Water Tube	0.25	0.40	0.70
H. R. T.	0.20	0.30	0.45
Vertical	0.10	0.15	0.20

As heating boilers are seldom run at any overload, 0.25 or 0.30 may be taken as covering the draft loss in any such boiler.

Economizers add 0.30 in. to the draft loss.

Draft losses for bends and smoke breeching are:

Steel Flues per 100 ft. run 0.10 in.; for each 90° bend, 0.05 in.

Concrete per 100 ft. run, 0.20 in.; for each 90° bend, 0.10 in.

Note.—Include every bend from the boiler uptake to the stack, counting the turn upward in the stack as one bend.

CHIMNEYS.

Draft Loss, Theoretical and Effectual.

The draft loss in the stack should run about 0.20 in. per 100 ft. of height in order to get economical construction.

The "effective" draft is the theoretical draft produced by the stack, with gases at a given temperature, less the loss produced by friction. The theoretical draft is shown by the curves in Sheet No. 100-F.

Air at higher elevation than sea level expands and requires a chimney of larger area to handle the same number of pounds at the same velocity and friction loss. The table below gives the percentage of increase for various heights up to 10,000 ft. above sea level.

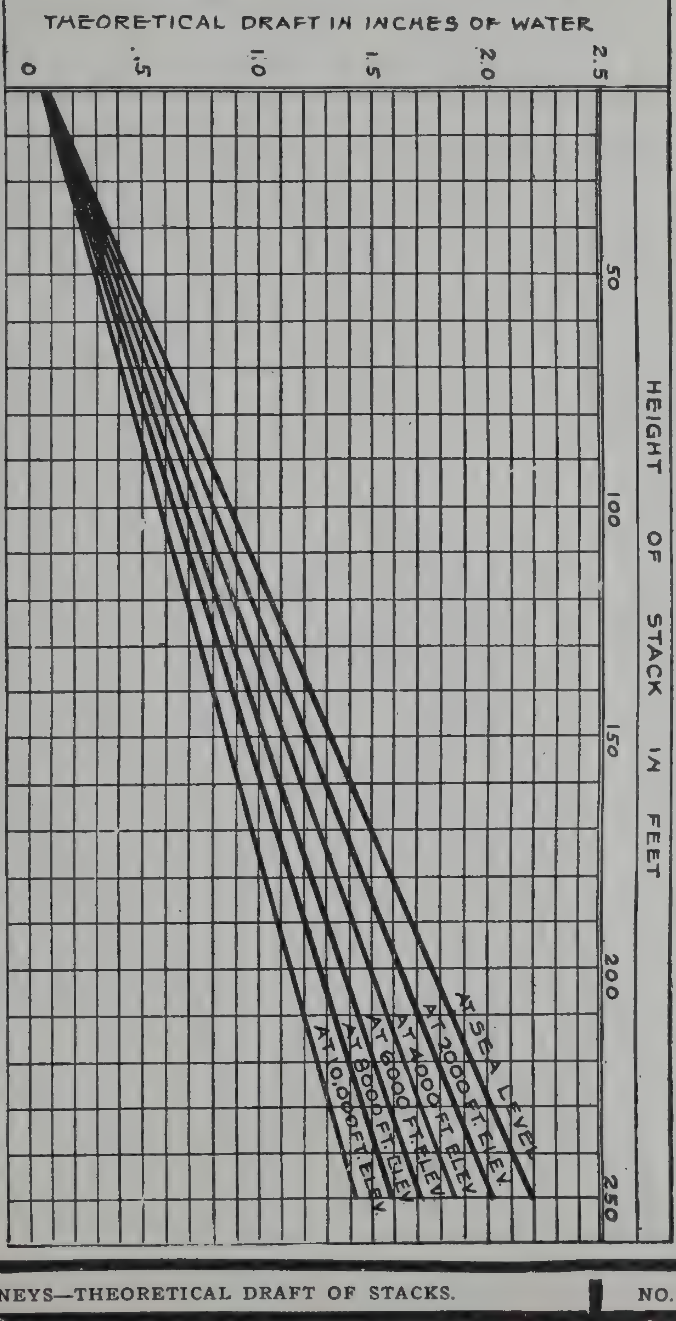
FACTORS OF AIR AT VARIOUS ELEVATIONS.

Elevations Above Sea Level Feet	Air Pressure Per Sq. in. in Pounds	Cubic Feet Per Lb.	Increase In Volume %
0	14.7	13.33	0.000
1,000	14.2	13.80	0.034
2,000	13.7	14.31	0.073
3,000	13.2	14.84	0.113
4,000	12.7	15.43	0.158
5,000	12.2	16.07	0.203
6,000	11.7	16.75	0.257
8,000	10.7	18.31	0.373
10,000	9.7	20.20	0.514

FORMULA: $D = .52 \times H \times P\left(\frac{1}{T} - \frac{1}{t}\right)$ WHEN "D" IS THEO. DRAFT, "H" HEIGHT OF STACK, "P" AIR PRESSURE IN LBS., "T" AB. OUTSIDE TEMP, & "t" AB. STACK TEM.

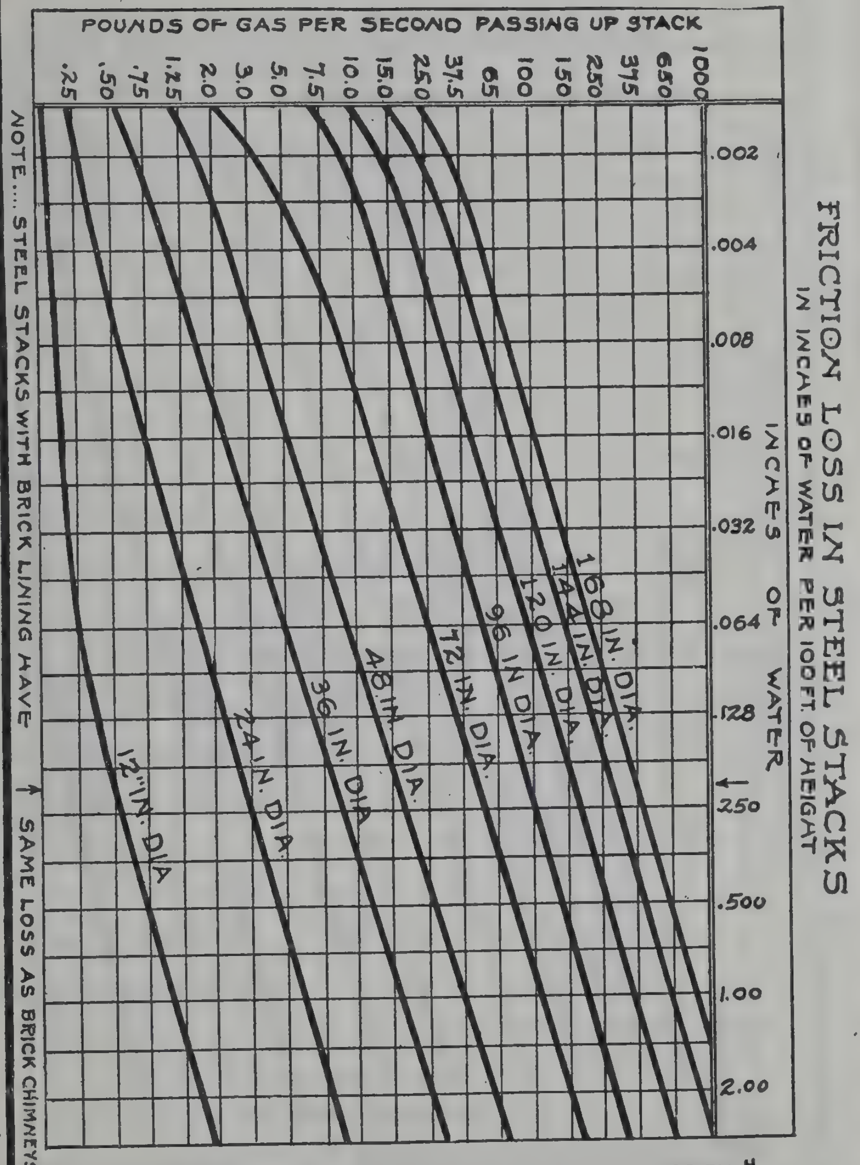
THEORETICAL DRAFT OF STACKS

WITH OUTSIDE TEMP ZERO, STACK TEMP. 500°F



NOTE. THEORETICAL DRAFT NEGLECTS ALL FRICTION, AND MUST EQUAL OR EXCEED ALL DRAFT LOSSES BY FRICTION INCLUDING LOSSES IN STACK ITSELF, BOILER BREECHING, ELBOWS, BOILER FLUES, FIRE BED AND GRATES AND ECONOMIZER (IF USED).

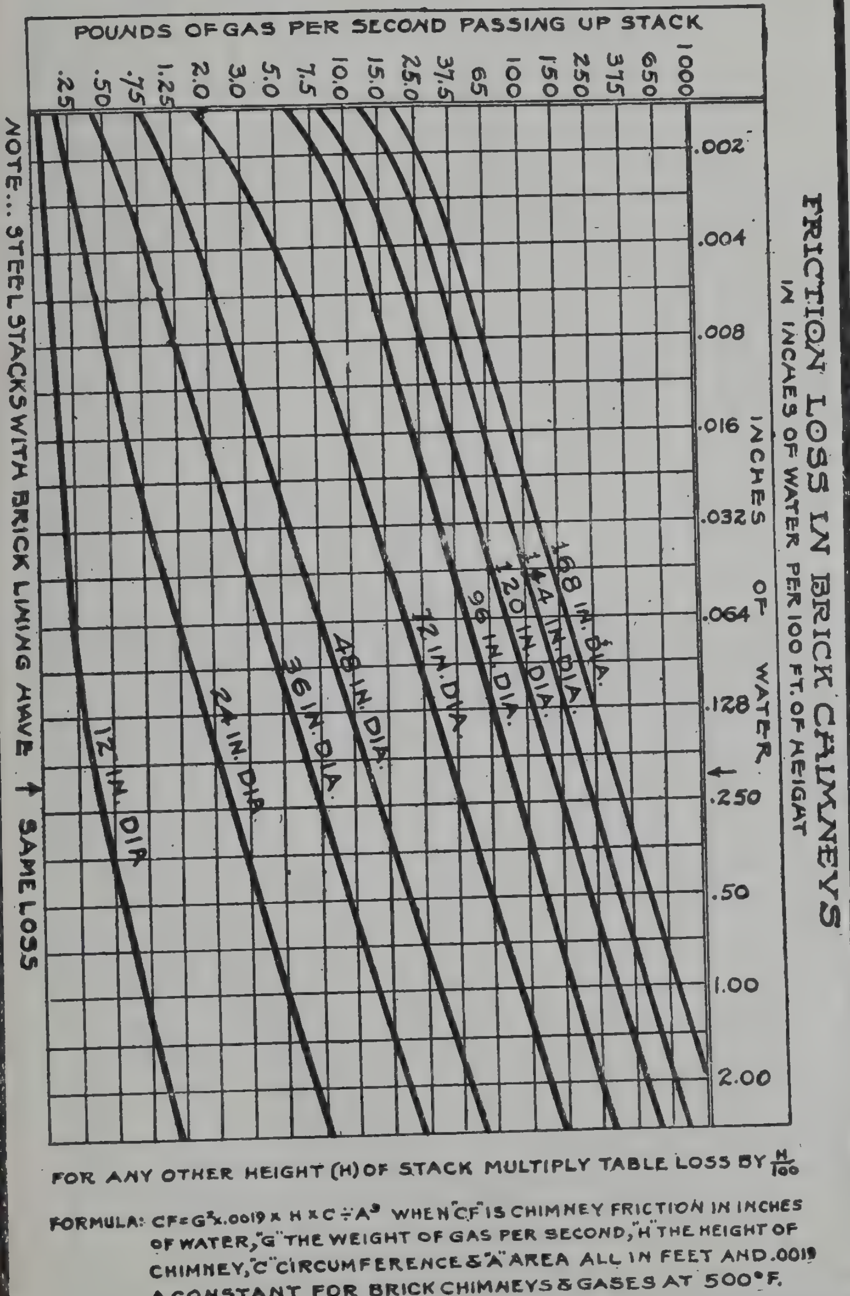
THE HEATING AND VENTILATING MAGAZINE–1123 BROADWAY–N.Y. CITY.



FOR ANY OTHER HEIGHT (H) OF STACK MULTIPLY TABLE LOSS BY $\frac{H}{100}$

FORMULA: $CF = G^2 \times .0014 \times H \times C \div A^3$ WHEN "CF" IS CHIMNEY FRICTION IN INCHES OF WATER, "G" THE WEIGHT OF GAS PER SECOND, "H" THE HEIGHT OF STACK, "C" CIRCUMFERENCE & "A" AREA ALL IN FEET AND .0014 A CONSTANT FOR STEEL STACKS & GASES AT 500° F.

CHIMNEYS—FRICTION LOSSES IN STEEL STACKS	No. 100-G



FOR ANY OTHER HEIGHT (H) OF STACK MULTIPLY TABLE LOSS BY $\frac{H}{100}$

FORMULA: $CF = G^2 \times .0019 \times H \times C \div A^3$ WHEN "CF" IS CHIMNEY FRICTION IN INCHES OF WATER, "G" THE WEIGHT OF GAS PER SECOND, "H" THE HEIGHT OF CHIMNEY, "C" CIRCUMFERENCE & "A" AREA ALL IN FEET AND .0019 A CONSTANT FOR BRICK CHIMNEYS & GASES AT 500°F.

CHIMNEYS—DRAFT LOSS IN BRICK STACKS. NO. 100-H

CHIMNEYS.

Summary and Draft Reading.

To summarize:

(*a*) Add together all friction losses (including those of the fire, boiler, breeching, turns, etc.) and allow 0.20 in. for chimney loss and 0.10 in. for safety. The result is the theoretical draft required to overcome all such losses.

(b) Read the required height of stack from the table of theoretical draft, using the line of proper elevation above sea level.

(*c*) Modify the loss in stack of 0.20 in. per hundred feet to suit the theoretical height found. Thus, for a theoretical draft requiring a stack 150 ft. high the 0.20 loss would become $0.20 \times \frac{150}{100} = 0.03$ and a new height must be re-read to offset the added friction.

(*d*) Read the diameter for brick or steel stacks on the basis of pounds of air per second handled and increase *area*—for heights above sea level—by percentage for increase of air volume.

Note: Measurement of the draft in a chimney is made by a draft gauge which, in its simplest form, is nothing but a glass tube of U-shape, one end of which is connected to the base of the chimney and the other end left open to the air.

The suction or draft of the chimney will raise water placed in the tube so that the water in the leg connected to the chimney stands higher than that in the leg open to the atmosphere, this being due to the unbalanced pressure and proportional thereto. The difference in level between the two columns of water is measured in inches, this difference being termed the draft in "inches of water." Some draft gauges have the legs of the U inclined only a few degrees off the horizontal so that a rise of small amount causes a large movement horizontally along the inclined tube on which fine graduations can be read.

To take a theoretical draft reading (which is the most accurate method to pursue) see that the temperature of the flue gases is known at the time of taking the reading and that a tight damper can be closed in the smoke pipe. Connect the draft gauge to the chimney, take the flue-gas temperature and then quickly close the smoke pipe damper and read the draft gauge as soon as it reaches the highest fixed point.

For points above sea level the readings will be *less* than that shown in the table, the percentages being for

2,000 ft.	97%
4,000 ft.	94%
6,000 ft.	92%
8,000 ft.	89%
10,000 ft.	86%

Thus, a chimney 50 ft. high and at 250° F. temperature at sea level should have a draft of 0.26 in., but at 6,000 ft. elevation it should have 0.26 × 92% or 0.24 in.

CHIMNEYS

Example for Steel Stack.

For example, suppose a steel stack, lined, at sea level is to be designed to serve:

Six—250 H. P. boilers, with four of them in service at 50% overload in extreme weather, or six in service at normal rating.

Coal to be burned, bituminous, run-of-mine;

Breeching, steel, 75 ft. long—square—

Turns, one—90° up from boiler,
One—90° into the breeching,
One—90° towards stack and
One—90° up into stack.

Turning to Standard Data Sheet No. 100-C and assuming 5 lbs. of coal per horsepower, it is found in the columns under the heading "Pounds of Coal per Boiler H. P." and in the column under the heading "5" that 1,500 B. H. P. will require 7,500 lbs. of coal per horsepower (in the extreme left-hand column) and that the "Pounds of Air per Second" (in the extreme right-hand column) is 38.

If each boiler has 80 sq. ft. of grate surface, with six boilers in service, the total grate surface would be 6 × 80 sq. ft., or 480 sq. ft., but with only four in service the total grate surface would be only 4 × 80 sq. ft., or 320 sq. ft.

7,500 lbs. of coal 1/320 = 24 lbs. per square foot at 150% rating.
7,500 lbs. of coal 1/480 = 16 lbs. per square foot at 100% rating.

On Standard Data Sheet No. 100-D it is found that the fire loss for run-of-mine bituminous coal at 25 lbs. per square foot is 0.14 in. and, for 15 lbs. per square foot, 0.08 in.

The boiler loss may be assumed at 0.25 in., at full rating, or 0.40 in., at 150%.

Smoke-breeching loss totals:

0.1 × 75/100 = 0.075 for straight pipe
Four bends @ 0.05 = 0.20 for bends.

0.28 in. total for bends and breeching.

Assumed for stack, 0.2 in. per 100 ft. of height

The total draft loss is then equal at

	100% Rating Inches water.	150% Rating Inches Water.
Fire	0.08	0.14
Boiler	0.25	0.40
Breeching	0.28	0.28
Stack	0.20	0.20
Contingencies	0.10	0.10
	0.91	1.12

From Standard Data Sheet 100-F the curve at sea level shows that the stack (for 100% rating) must be about 103 ft. high, increasing its friction loss to 0.2 in. × 103/100 = 0.21 in. making 0.92 total, requiring, possibly, 103 ft. actual height. As the stack is lined, the friction loss will be the same as a brick chimney and on Standard Data Sheet No. 100-H the point under the arrow and opposite 38 lbs. of air per second is found to be almost on the 72-in. line, this diameter of stack being correct for the 100% rating.

For 150% rating, by similar procedure, the required height of stack is found on Standard Data Sheet No. 100-F to be 127 ft. and the friction loss will be 0.2 × 127/100 = 0.25, or 1.17 in. making about 130 ft. height required. Since, under these conditions, the chimney friction loss is 0.25 in., by referring to Standard Data Sheet No. 100-H—opposite 38 lbs. of air per second and under 0.25 in. loss, the intersection falls on 72 in. diameter exactly. This shows that the diameter is the same in each case because, of course, the quantity of gas is the same, but the height must be increased when forcing the four boilers to 150% of their ratings.

Now suppose this stack were to be located at a point 5,000 ft. above sea level. Then the theoretical draft must be 1.12 in. as before, but, referring to Standard Data Sheet No. 100-F, it is found that 5,000 ft. requires a stack 158 ft. high. The friction loss is then 0.2 × 158/100 = 0.31 in. and this will increase the total friction by 0.31—0.2 or 0.11 in., making 112 + 0.11 = 1.23 in. This re-applied to the curve shows a stack actually required 172 ft. in height.

Then, with a stack friction of 0.31 in. of water, on Standard Data Sheet No. 100-H, under 0.31 in. and opposite 38 lbs. of gas per second is found a point close to the 72 in. diameter line. Reference to the table on Standard Data Sheet 100-E shows that the volume at 5,000 ft. is increased 20%. The area of a 72-in. stack is about 28 sq. ft. which, increased by 20%, is 28 + 28 × 0.2, or 33 sq. ft. which is about a 78-in. stack.

CHIMNEYS.

Costs.

As far as the cost of chimneys is concerned, this is a rather variable amount and depends on the material of construction, the foundation necessary, location of job, etc. The ordinary materials of construction are common red brick, radial brick, steel and concrete. Steel stacks are divided into lined and unlined or partially lined and also into self-supporting and guyed stacks. Steel is the most unstable of the materials mentioned, these stacks lasting 10 to 12 years and requiring frequent painting; they rust rapidly when not in service Lined steel stacks have a lining of fire brick to protect them from the action and heat of the gases contained.

Brick stacks last a long time, while concrete is practically indestructible if properly erected. Radial brick chimneys are built of special radial brick which have five or six holes about 1 in. in diameter running through them vertically.

The cost of chimneys per horsepower will run about as follows for the maximum horsepower which they will handle:

Up to 100 ft. high	4 ft. to 6 ft. dia.,	$2.50 to $4.50 per H.P.
Up to 125 ft. high	6 ft. to 12 ft. dia.,	2.30 to 3.75 per H.P.
Up to 150 ft. high	8 ft. to 14 ft. dia.,	1.75 to 2.75 per H.P.
Up to 175 ft. high	10 ft. to 14 ft. dia.,	1.75 to 2.00 per H.P.
Up to 200 ft. high	12 ft. or over dia.	2.00 per H.P.

If the cost of a radial brick stack be taken as unity the comparative cost of other constructions will vary about as follows:

	Cost per Horsepower
Radial Brick	1.00
Common Red Brick	1.25
Steel,—self-supporting,—lined	1.23
Steel,—self-supporting,—partially lined	1.14
Steel,—self-supporting,—unlined	.86
Steel,—guyed, lined	1.00
Steel,—guyed, partially lined	.80
Steel,—guyed, unlined	.60

RULES FOR FLANGED FITTINGS.

American 1915 Standard, Standard Weight.

1. Standard reducing elbows carry same dimensions center-to-face as regular elbows of largest straight size.

2. Standard tees, crosses and laterals, reducing on run only, carry same dimensions face-to-face as largest straight size.

3. Where long-turn fittings are specified, it has reference only to elbows which are made in two center-to-face dimensions and to be known as "elbows" and "long-turn elbows," the latter being used only when so specified.

4. All standard weight fittings must be guaranteed for 125 lbs. working pressure, and each fitting must have some mark cast on it indicating the maker and guaranteed working steam pressure.

5. Standard weight fittings and flanges to be plain faced, and bolt holes to be ⅛ in. larger in diameter than bolts; bolt holes to straddle center lines.

6. Size of all fittings scheduled indicates inside diameter of ports.

7. Square head bolts with hexagonal nuts are generally recommended for use.

8. Double-branch elbows, side-outlet elbows and side-outlet tees, whether straight or reducing sizes, carry same dimensions center-to-face and face-to-face as regular tees and elbows.

9. Bull-head tees or tees increasing on outlet, will have same center-to-face and face-to-face dimensions as a straight fitting of the size of the outlet.

10. Tees, crosses and laterals 16-in. and smaller, reducing on the outlet, use the same dimensions as straight sizes of the larger port.

Sizes 18-in. and larger, reducing on the outlet, are made in two lengths, depending on the size of the outlet, as given in the table of dimensions.

11. For fittings reducing on the run only, a long-body pattern will be used. Y's are special and made to suit connections. Double-branch elbows are not made reducing on the run.

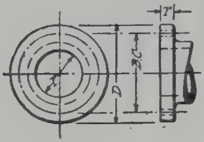
12. Steel flanges, fittings and valves are recommended for superheated steam.

13. If flanged fittings for lower working pressure than 125 lbs. are made, they shall conform in all dimensions, except thickness of shell, to this standard and shall have the guaranteed working pressure cast on each fitting. Flanges for these fittings must be standard dimensions.

FITTINGS.

1915 Standard Weight Flanges and Bolts.

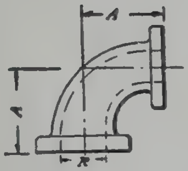
125 Lbs. Working Pressure.



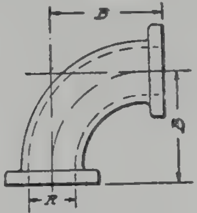
PIPE	FLANGE		BOLTS			Bolt Holes
Size in. diam. P	Diam. in. D	Thickness in, T	No.	Size In. diam.	Bolt circle In. B. C.	Size In. diam.
1	4	7/16	4	7/16	3	9/16
1 1/4	4 1/2	1/2	4	7/16	3 3/8	9/16
1 1/2	5	9/16	4	1/2	3 7/8	5/8
2	6	5/8	4	5/8	4 3/4	3/4
2 1/2	7	11/16	4	5/8	5 1/2	3/4
3	7 1/2	3/4	4	5/8	6	3/4
3 1/2	8 1/2	13/16	4	5/8	7	3/4
4	9	15/16	8	5/8	7 1/2	3/4
4 1/2	9 1/4	15/16	8	3/4	7 3/4	7/8
5	10	15/16	8	3/4	8 1/2	7/8
6	11	1	8	3/4	9 1/2	7/8
7	12 1/2	1 1/16	8	3/4	10 3/4	7/8
8	13 1/2	1 1/8	8	3/4	11 3/4	7/8
9	15	1 1/8	12	3/4	13 1/4	7/8
10	16	1 3/16	12	7/8	14 1/4	1
12	19	1 1/4	12	7/8	17	1
14	21	1 3/8	12	1	18 3/4	1 1/8
15	22 1/4	1 3/8	16	1	20	1 1/8
16	23 1/2	1 7/16	16	1	21 1/4	1 1/8
18	25	1 9/16	16	1 1/8	22 3/4	1 1/4
20	27 1/2	1 11/16	20	1 1/8	25	1 1/4
22	29 1/2	1 13/16	20	1 1/4	27 1/4	1 3/8
24	32	1 7/8	20	1 1/4	29 1/2	1 3/8
26	34 1/4	2	24	1 1/4	31 3/4	1 3/8
28	36 1/2	2 1/16	28	1 1/4	34	1 3/8
30	38 3/4	2 1/8	28	1 3/8	36	1 1/2
32	41 3/4	2 1/4	28	1 1/2	38 1/2	1 5/8
34	43 3/4	2 5/16	32	1 1/2	40 1/2	1 5/8
36	46	2 3/8	32	1 1/2	42 3/4	1 5/8
38	48 3/4	2 3/8	32	1 5/8	45 1/4	1 3/4
40	50 3/4	2 1/2	36	1 5/8	47 1/4	1 3/4

1915 Standard Weight Elbows and Reducers.

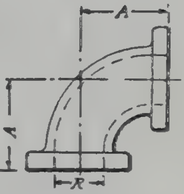
125 Lbs. Working Pressure



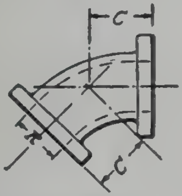
Elbow.



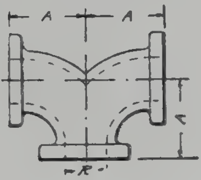
Long-Turn Elbow.



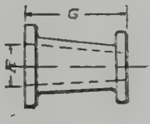
Reducing Elbow.



45° Elbow.



Double-Branch Elbow.

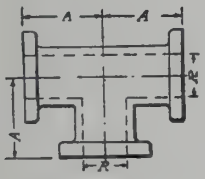


Reducer.

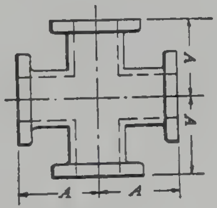
SIZE In. Diam.	DIMENSIONS, In.				FLANGE	
R	A	B	C	G	Diam. In.	Thickness In.
1	3 1/2	5	1 3/4	—	4	7/16
1 1/4	3 3/4	5 1/2	2	—	4 1/2	1/2
1 1/2	4	6	2 1/4	—	5	9/16
2	4 1/2	6 1/2	2 1/2	—	6	5/8
2 1/2	5	7	3	—	7	11/16
3	5 1/2	7 3/4	3	6	7 1/2	3/4
3 1/2	6	8 1/2	3 1/2	6 1/2	8 1/2	13/16
4	6 1/2	9	4	7	9	15/16
4 1/2	7	9 1/2	4	7 1/2	9 1/4	15/16
5	7 1/2	10 1/4	4 1/2	8	10	15/16
6	8	11 1/2	5	9	11	1
7	8 1/2	12 3/4	5 1/2	10	12 1/2	1 1/16
8	9	14	5 1/2	11	13 1/2	1 1/8
9	10	15 1/4	6	11 1/2	15	1 1/8
10	11	16 1/2	6 1/2	12	16	1 3/16
12	12	19	7 1/2	14	19	1 1/4
14	14	21 1/2	7 1/2	16	21	1 3/8
15	14 1/2	22 3/4	8	17	22 1/4	1 3/8
16	15	24	8	18	23 1/2	1 7/16
18	16 1/2	26 1/2	8 1/2	19	25	1 9/16
20	18	29	9 1/2	20	27 1/2	1 11/16
22	20	31 1/2	10	22	29 1/2	1 13/16
24	22	34	11	24	32	1 7/8
26	23	36 1/2	13	26	34 1/4	2
28	24	39	14	28	36 1/2	2 1/16
30	25	41 1/2	15	30	38 3/4	2 1/8
32	26	44	16	32	41 3/4	2 1/4
34	27	46 1/2	17	34	43 3/4	2 5/16
36	28	49	18	36	46	2 3/8
38	29	51 1/2	19	38	48 3/4	2 3/8
40	30	54	20	40	50 3/4	2 1/2

1915 Standard Weight Crosses and Laterals.

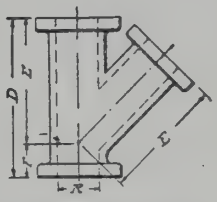
125 Lbs. Working Pressure



STRAIGHT TEE.



STRAIGHT CROSS.

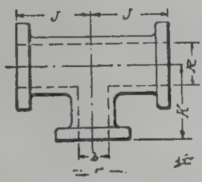


STRAIGHT LATERAL.

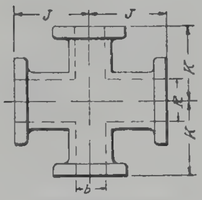
SIZE In. Diam.	DIMENSIONS In.			FLANGES	
R	A	D	E	Diam. In.	Thickness In.
1	3 1/2	7 1/2	5 3/4	4	7 16
1 1/4	3 3/4	8	6 1/4	4 1/2	1/2
1 1/2	4	9	7	5	9/16
2	4 1/2	10 1/2	8	6	5/8
2 1/2	5	12	9 1/2	7	11/16
3	5 1/2	13	10	7 1/2	3/4
3 1/2	6	14 1/2	11 1/2	8	13/16
4	6 1/2	15	12	9	15/16
4 1/2	7	15 1/2	12 1/2	9 1/4	15/16
5	7 1/2	17	13 1/2	10	15/16
6	8	18	14 1/2	11	1
7	8 1/2	20 1/2	16 1/2	12 1/2	11/16
8	9	22	17 1/2	13 1/2	1 1/8
9	10	24	19 1/2	15	1 1/8
10	11	25 1/2	20 1/2	16	1 3/16
12	12	30	24 1/2	19	1 1/4
14	14	33	27	21	1 3/8
15	14 1/2	34 1/2	28 1/2	22 1/4	1 3/8
16	15	36 1/2	30	23 1/2	1 7/16
18	16 1/2	39	32	25	1 9/16
20	18	43	35	27 1/2	1 11/16
22	20	46	37 1/2	29 1/2	1 13/16
24	22	49 1/2	40 1/2	32	1 7/8
26	23	53	44	34 1/4	2
28	24	56	46	36 1/2	2 1/16
30	25	59	49	38 3/4	2 1/8
32	26	—	—	41 3/4	2 1/4
34	27	—	—	43 3/4	2 5/16
36	28	—	—	46	2 3/8
38	29	—	—	48 3/4	2 3/8
40	30	—	—	50 3/4	2 1/2

FITTINGS—Std. Wt. Straight Tee Crosses and Laterals, Flanged. NO. 107-C.

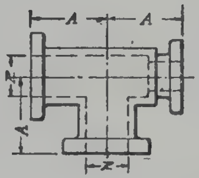
STANDARD BULL-HEAD REDUCING TEES AND CROSSES—FLANGED



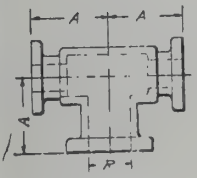
Reducing Tee



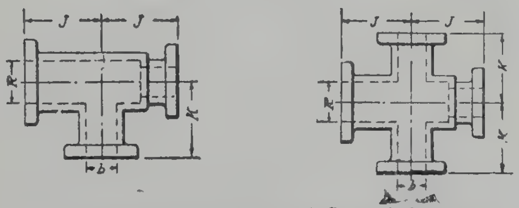
Reducing Cross



Reducing-on-Run Tee



Bullhead Tee.



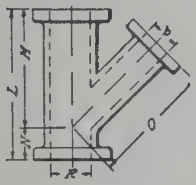
Reducing-on-Run and Branch Tee and Cross.

	SIZE In. Diam.		DIMENSIONS, IN.		FLANGES	
R	BRANCH "B"		A&J	K	Diam. In.	Thickness In.
1					4	7/16
1 1/4	1	or less	3 3/4	3 3/4	4 1/2	1/2
1 1/2	1 1/4	" "	4	4	5	9/16
2	1 1/2	" "	4 1/2	4 1/2	6	5/8
2 1/2	2	" "	5	5	7	11/16
3	2 1/2	" "	5 1/2	5 1/2	7 1/2	3/4
3 1/2	3	" "	6	6	8 1/2	13/16
4	3 1/2	" "	6 1/2	6 1/2	9	15/16
4 1/2	4	" "	7	7	9 1/4	15/16
5	4 1/2	" "	7 1/2	7 1/2	10	15/16
6	5	" "	8	8	11	1
7	6	" "	8 1/2	8 1/2	12 1/2	1 1/16
8	7	" "	9	9	13 1/2	1 1/8
9	8	" "	10	10	15	1 1/8
10	9	" "	11	11	16	1 3/16
12	10	" "	12	12	19	1 1/4
14	12	" "	14	14	21	1 3/8
15	14	" "	14 1/2	14 1/2	22 1/4	1 3/8
16	15	" "	15	15	23 1/2	1 7/16
18	18 to 14 inc.		16 1/2	16 1/2	25	1 9/16
20	20 to 15 inc.		18	18	27 1/2	1 11/16
22	22 to 16 inc.		20	20	29 1/2	1 13/16
24	24 to 18 inc.		22	22	32	1 7/8
26	26 to 20 inc.		23	23	34 1/4	2
28	28 to 20 inc.		24	24	36 1/2	2 1/16
30	30 to 22 inc.		25	25	38 3/4	2 1/8
32	32 to 22 inc.		26	26	41 3/4	2 1/4
34	34 to 24 inc.		27	27	43 3/4	2 5/16
36	36 to 26 inc.		28	28	46	2 3/8
38	38 to 26 inc.		29	29	48 3/4	2 3/8
40	40 to 28 inc.		30	30	50 3/4	2 1/2

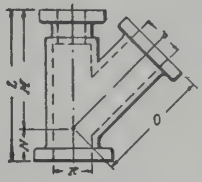
Note—A reduction in size *on the run* does not affect the dimensions but branch outlet of small size Such as are listed below will reduce the dimensions of fittings 18 in. or over in size.

Branch "b"		J	K
12	or less	13	15 1/2
14	" "	14	17
15	" "	14	18
16	" "	15	19
18	" "	16	20
18	" "	16	21
20	" "	18	23
20	" "	18	24
22	" "	19	25
24	" "	20	26
24	" "	20	28
26	" "	22	29

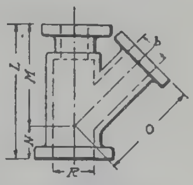
1915 STANDARD WEIGHT FLANGED REDUCING LATERALS.



Reducing Lateral.



Reducing-on-Run Lateral.

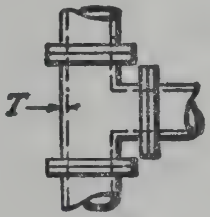


Reducing-on-Run-and Branch Lateral.

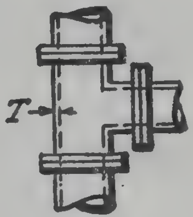
Size, In. Diam. R	Branch b	Dimensions, In. L	M	N	O	Flanges Dia. In.	Thickness In.
1	—			—	—	4	7/16
1¼	1¼ or less	8	6¼	1¾	6¼	4½	½
1½	1½ " "	9	7	2	7	5	9/16
2	2 " "	10½	8	2½	8	6	⅝
2½	2½ " "	12	9½	2½	9½	7	11/16
3	3 " "	13	10	3	10	7½	¾
3½	3½ " "	14½	11½	3	11½	8½	13/16
4	4 " "	15	12	3	12	9	15/16
4½	4½ " "	15½	12½	3	12½	9¼	15/16
5	5 " "	17	13½	3½	13½	10	15/16
6	6 " "	18	14½	3½	14½	11	1
7	7 " "	20½	16½	4	16½	12½	1 1/16
8	8 " "	22	17½	4½	17½	13½	1⅛
9	9 " "	24	19½	4½	19½	15	1⅛
10	10 " "	25½	20½	5	20½	16	1 3/16
12	12 " "	30	24½	5½	24½	19	1¼
14	14 " "	33	27	6	27	21	1⅜
15	15 " "	34½	28½	6	28½	22¼	1⅜
16	16 " "	36½	30	6½	30	23½	1 7/16
18	9 " "	26	25	1	27½	25	1 9/16
18	18 to 10 inc.	39	32	7	32	25	1 9/16
20	10 and less	28	27	1	29½	27½	1 11/16
20	20 to 12 inc.	43	35	8	35	27½	1 11/16
22	10 and less	29	28½	½	31½	29½	1 13/16
22	22 to 12 inc	46	37½	8½	37½	29½	1 13/16
24	12 and less	32	31½	½	34½	32	1⅞
24	24 to 14 inc.	49½	40½	9	40½	32	1⅞
26	12 and less	35	35	0	38	34¼	2
26	26 to 14 inc.	53	44	9	44	34¼	2
28	14 and less	37	37	0	40	36½	2 1/16
28	28 to 15 inc.	56	46½	9½	46½	36½	2 1/16
30	15 and less	39	39	0	42	38¾	2⅛
30	30 to 16 inc.	59	49	10	49	38¾	2⅛

SHELL THICKNESS OF FLANGED FITTINGS

Standard Weight
125 Lbs. Working Pressure.



Extra Heavy
250 Lbs. Working Pressure



Nominal size of Fitting, Inches.	Thickness of Shell T, Inches.	Nominal size of Fitting, Inches.	Thickness of Shell T, Inches.
2	7/16	2	⅝
2½	7/16	2½	⅝
3	½	3	⅝
3½	½	3½	⅝
4	½	4	⅝
4½	½	4½	11/16
5	½	5	¾
6	9/16	6	13/16
7	⅝	7	⅞
8	11/16	8	15/16
9	¾	9	1
10	13/16	10	1 1/16
12	⅞	12	1 ⅛
14	15/16	14	1 3/16
15	15/16	15	1 ¼
16	15/16	16	1 5/16
18	1	18	1 7/16
20	1 1/16	20	1 ½

RULES FOR FLANGED FITTINGS.

American 1915 Standard, Extra Heavy.

1. Extra heavy reducing elbows carry same dimensions center to face as regular elbows of largest straight size.

2. Extra heavy tees, crosses and laterals, reducing on run only, carry same dimensions face to face as largest straight size.

3. Where long turn fittings are specified, it has reference only to elbows which are made in two center to face dimensions and to be known as elbows and long-turn elbows, the latter being used only when so specified.

4. Extra heavy fittings must be guaranteed for 250 lbs. working pressure, and each fitting must have some mark cast on it indicating the maker and guaranteed working steam pressure.

5. All extra heavy fittings and flanges to have a raised surface 1/16-in. high inside of bolt holes for gaskets. Thickness of flanges and center to face dimensions of fittings include this raised surface. Bolt holes to be ⅛-in. larger in diameter than bolts. Bolt holes to straddle center lines.

6. Size of all fittings scheduled indicates inside diameter of ports.

7. Square head bolts with hexagonal nuts are generally recommended for use.

8. Double branch elbows, side outlet elbows and side outlet tees, whether straight or reducing sizes, carry same dimensions center to face and face to face as regular tees and elbows.

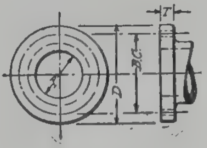
9. Bull head tees or tees increasing on outlet, will have same center-to-face and face-to-face dimensions as a straight fitting of the size of the outlet.

10. Tees, crosses and laterals 16-in. and smaller, reducing on the outlet, use the same dimensions as straight size of the larger port. Sizes 18-in. and larger, reducing on the outlet, are made in two lengths, depending on the size of the outlet as given in the table of dimensions.

11. For fittings reducing on the run only a long body pattern will be used. Y's are special and made to suit connections. Double branch elbows are not made reducing on the run.

12. Steel flanges, fittings and valves are recommended for superheated steam.

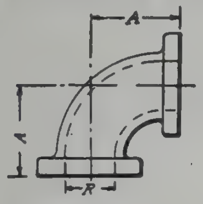
1915 STANDARD EXTRA HEAVY PIPE FLANGES AND BOLTS.



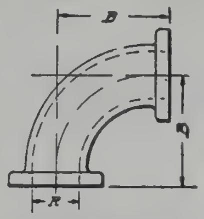
250 LBS. WORKING PRESSURE

Pipe Size	FLANGE Dia. D	FLANGE Thickness T	BOLTS No.	BOLTS Size	BOLTS BoltCircle B.C.	BOLTS BoltHole
1	4½	11/16	4	½	3¼	⅝
1¼	5	¾	4	½	3¾	⅝
1½	6	13/16	4	⅝	4½	¾
2	6½	⅞	4	⅝	5	¾
2½	7½	1	4	¾	5⅞	⅞
3	8¼	1 ⅛	8	¾	6⅝	⅞
3½	9	1 3/16	8	¾	7¼	⅞
4	10	1 ¼	8	¾	7⅞	⅞
4½	10½	1 5/16	8	¾	8½	⅞
5	11	1 ⅜	8	¾	9¼	⅞
6	12½	7 1/16	12	¾	10⅝	⅞
7	14	1 ½	12	⅞	11⅞	1
8	15	1 ⅝	12	⅞	13	1
9	16¼	1 ¾	12	1	14	1⅛
10	17½	1 ⅞	16	1	15¼	1⅛
12	20½	2	16	1⅛	17¾	1¼
14	23	2 ⅛	20	1⅛	20¼	1¼
15	24½	2 3/16	20	1¼	21½	1⅜
16	25½	2 ¼	20	1¼	22½	1⅜
18	28½	2 ⅜	24	1¼	24¾	1⅜
20	30½	2 ½	24	1⅜	27	1½
22	33	2 ⅝	24	1½	29¼	1⅝
24	36	2 ¾	24	1⅝	32	1¾
26	38¼	2 13/16	28	1⅝	34½	1¾
28	40¾	2 15/16	28	1⅝	37	1¾
30	43	3	28	1¾	39¼	1⅞
32	45¼	3 ⅛	28	1⅞	41½	2
34	47½	3 ¼	28	1⅞	43½	2
36	50	3 ⅜	32	1⅞	46	2
38	52¼	3 7/16	32	1⅞	48	2
40	54½	3 9/16	36	1⅞	50¼	2

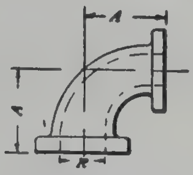
1915 STANDARD EXTRA HEAVY ELBOWS AND REDUCERS.



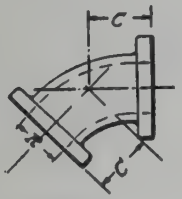
Elbow.



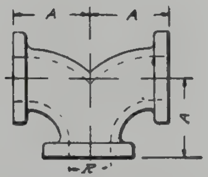
Long-TurnElbow.



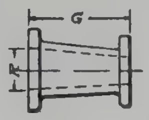
ReducingElbow.



45° Elbow.



Double-Branch
Elbow.

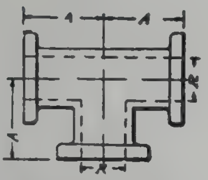


Reducer.

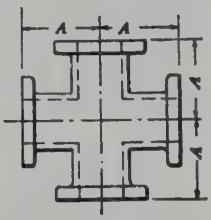
250 LBS. WORKING PRESSURE

Size	Dimensions				Flange	
R	A	B	C	G	Dia.	Thickness
1	4	5	2	—	4½	11/16
1¼	4¼	5½	2½	—	5	¾
1½	4½	6	2¾	—	6	13/16
2	5	6½	3	—	6½	⅞
2½	5½	7	3½	—	7½	1
3	6	7¾	3½	6	8¼	1 ⅛
3½	6½	8½	4	6½	9	1 3/16
4	7	9	4½	7	10	1 ¼
4½	7½	9½	4½	7½	10½.	1 5/16
5	8	10¼	5	8	11	1 ⅜
6	8½	11½	5½	9	12½	1 7/16
7	9	12¾	6	10	14	1 ½
8	10	14	6	11	15	1 ⅝
9	10½	15¼	6½	11½	16¼	1 ¾
10	11½	16½	7	12	17½	1 ⅞
12	13	19	8	14	20½	2
14	15	21½	8½	16	23	2 ⅛
15	15½	22¾	9	17	24½	2 3/16
16	15½	24	9½	18	25½	2 ¼
18	18	26½	10	19	28	2 ⅜
20	19½	29	10½	20	30½	2 ½
22	20½	31½	11	22	33	2 ⅝
24	22½	34	12	24	36	2 ¾
26	24	36½	13	26	38¼	2 13/16
28	26	39	14	28	40¾	2 15/16
30	27½	41½	15	30	43	3
32	29	44	16	32	45¼	3 ⅛
34	30½	46½	17	34	47½	3 ¼
36	32½	49	18	36	50	3 ⅜
38	34	51½	19	38	52¼	3 7/16
40	35½	54	20	40	54½	3 9/16

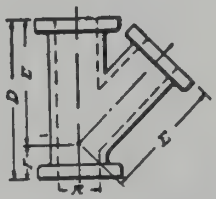
1915 STANDARD EXTRA-HEAVY STRAIGHT TEES, CROSSES AND LATERALS, FLANGED.



STRAIGHT TEE.



STRAIGHT CROSS.



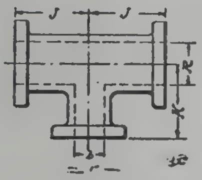
STRAIGHT LATERAL.

250 LBS. WORKING PRESSURE

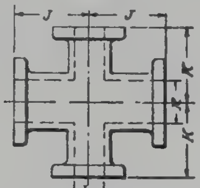
Size, In. Diam.	Dimensions. In.			Flanges	
R	A	D	E	Diam. In.	Thickness, In.
1	4	8½	6½	4½	11/16
1¼	4¼	9½	7¼	5	¾
1½	4½	11	8½	6	13/16
2	5	11½	9	6½	⅞
2½	5½	13	10½	7½	1
3	6	14	11	8¼	1 ⅛
3½	6½	15½	12½	9	1 ⅜
4	7	16½	13½	10	1 ¼
4½	7½	18	14½	10½	1 5/16
5	8	18½	15	11	1 ⅜
6	8½	21½	17½	12½	1 7/16
7	9	23½	19	14	1 ½
8	10	25½	20½	15	1 ⅝
9	10½	27½	22½	16¼	1 ¾
10.	11½	29½	24	17½	1 ⅞
12	13	33½	27½	20½	2
14	15	37½	31	23	2 ⅛
15	15½	39½	33	24½	2 3/16
16	16½	42	34½	25½	2 ¼
18	18	45½	37½	28	2 ⅜
20	19½	49	40½	30½	2 ½
22	20½	53	43½	33	2 ⅝
24	22½	57½	47½	36	2 ¾
26	24	——	——	38¼	2 13/16
28	26	——	——	40¾	2 15/16
30	27½	——	——	43	3
32	29	——	——	45¼	3 ⅛
34	30½	——	——	47½	3 ¼
36	32½	——	——	50	3 ⅜
38	34	——	——	52¼	3 7/16
40	35½	——	——	54½	3 9/16

FITTINGS, EXTRA HEAVY—Straight Tees, Crosses and Flanged Laterals NO. 108-C.

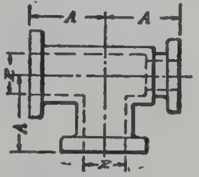
1915 STANDARD EXTRA-HEAVY BULL-HEAD REDUCING TEES AND CROSSES, FLANGED.



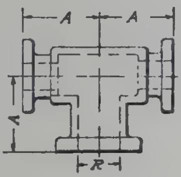
Reducing Tee



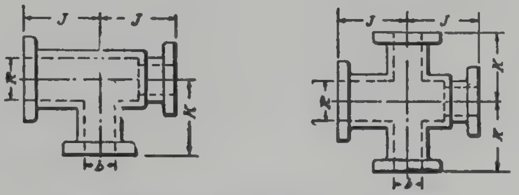
Reducing Cross



Reducing-on-Run Tee



Bullhead Tee.



Reducing-on Run and Branch Tee and Cross.

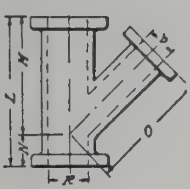
250 IBS. WORKING PRESSURE

Size, In. Diam.		Dimensions, In.					Flanges	
Run	Branch	J	K	Branch	J	K	Diam. In.	Thickness In.
1	——	——	——				4½	11/16
1¼	1 or less	4¼	4¼				5	¾
1½	1¼ or less	4½	4½				6	13/16
2	1½ or less	5	5				6½	⅞
2½	2 or less	5½	5½				7½	1
3	2½ or less	6	6				8¼	1 ⅛
3½	3 or less	6½	6½				9	1 3/16
4	3½ or less	7	7				10	1 ¼
4½	4 or less	7½	7½				10½	1 5/16
5	4½ or less	8	8				11	1 3/8
6	5 or less	8½	8½				12½	1 7/16
7	6 or less	9	9				14	1 ½
8	7 or less	10	10				15	1 ⅝
9	8 or less	10½	10½				16¼	1 ¾
10	9 or less	11½	11½				17½	1 ⅞
12	10 or less	13	13				20½	2
14	12 or less	15	15				23	2 ⅛
15	14 or less	15½	15½				24½	3 3/16
16	15 or less	16½	16½				25½	2 ¼
18	18 to 14 inc	18	18	12 or less	14	17	28	2 ⅜
20	20 to 15 inc.	19½	19½	14 or less	15½	18½	30½	2 ½
22	22 to 16 inc.	20½	20½	15 or less	16½	20	33	2 ⅝
24	24 to 18 inc.	22½	22½	16 or less	17	21½	36	2 ¾
26	26 to 20 inc.	24	24	18 or less	19	23	38¼	2 13/16
28	28 to 20 inc.	26	26	18 or less	19	24	40¾	2 15/16
30	30 to 22 inc.	27½	27½	20 or less	20½	25½	43	3
32	32 to 22 inc.	29	29	20 or less	20½	26½	45¼	3 ⅛
34	34 to 24 inc.	30½	30½	22 or less	22	28	47½	3 ¼
36	36 to 26 inc.	32½	32½	24 or less	23½	29½	50	3 ⅜
38	38 to 26 inc.	34	34	24 or less	23½	30½	25¼	3 7/16
40	40 to 28 inc.	35½	35½	26 or less	25	31½	54½	3 9/16

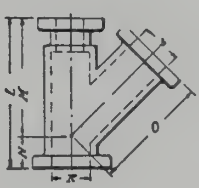
NOTE.—A reduction in size *on the run* does not affect the dimensions but branch outlets of smaller size than those listed below will reduce the dimensions of fittings 18 in. or over in size.

FITTINGS, EXTRA HEAVY—Bull-Head Reducing Tees and Crosses, NO. 108-D.

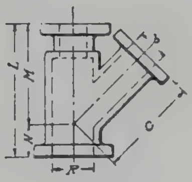
1915 STANDARD EXTRA HEAVY REDUCING LATERALS, FLANGED.



Reducing Lateral.



Reducing-on-Run Lateral.



Reducing-on-Run-and Branch Lateral.

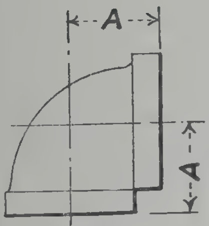
250 LBS. WORKING PRESSURE

Size, In. Diam. Run	Branch	Dimensions, In. L	M	N	O	Flanges Diam. In.	Thickness In.
1	—	—	—	—	—	4½	11/16
1¼	1¼ and less	9½	7¼	2¼	7¼	5	¾
1½	1½ “ “	11	8½	2½	8½	6	13/16
2	2 “ “	11½	9	2½	9	6½	⅞
2½	2½ “ “	13	10½	2½	10½	7½	1
3	3 “ “	14	11	3	11	8¼	1 ⅛
3½	3½ “ “	15½	12½	3	12½	9	1 3/16
4	4 “ “	16½	13½	3	13½	10	1 ¼
4½	4½ “ “	18	14½	3½	14½	10½	1 5/16
5	5 “ “	18½	15	3½	15	11	1 ⅜
6	6 “ “	21½	17½	4	17½	12½	1 7/16
7	7 “ “	23½	19	4½	19	14	1 ½
8	8 “ “	25½	20½	5	20½	15	1 ⅝
9	9 “ “	27½	22½	5	22½	16¼	1 ¾
10	10 “ “	29½	24	5½	24	17½	1 ⅞
12	12 “ “	33½	27½	6	27½	20½	2
14	14 “ “	37½	31	6½	31	23	2 ⅛
15	15 “ “	39½	33	6½	33	24½	2 3/16
16	16 “ “	42	34½	7½	34½	25½	2 ¼
18	9 “ “	34	31	3	32½	28	2 ⅜
18	16 to 10 inc.	45½	37½	8	37½	28	2 ⅜
20	10 and less	37	34	3	36	30½	2 ½
20	18 to 12 inc.	49	40½	8½	40½	30½	2 ½
22	10 and less	40	37	3	39	33	2 ⅝
22	20 to 12 inc.	53	43½	9½	43½	33	2 ⅝
24	12 and less	44	41	3	43	36	2 ¾
24	22 to 14 inc.	57½	47½	10	47½	36	2 ¾

FITTINGS.

Standard Weight Cast-Iron Screwed Fittings.

—125 Lbs. Working Pressure—



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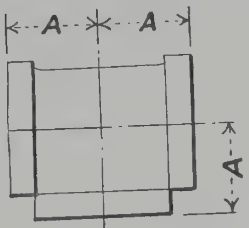
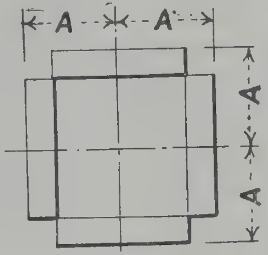


Tee



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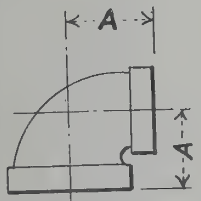
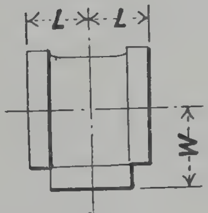
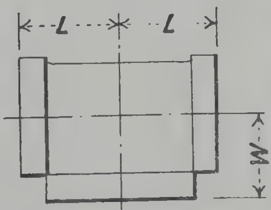


Red. Ell



Red. Tee



Bullhead Tee

Run x Branch In. Diam. In. Diam.	A In. Diam.	L In. Diam.	W In. Diam.
¼ Straight	13/16	....	....
¼ x ⅜ Bh.	....	15/16	15/16
⅜ Straight	15/16	....	....
⅜ x ¼ Red.	....	15/16	15/16
½ Straight	1 3/32	....	....
½ x ¾ Bh.	....	1 1/4	1 5/32
½ x 1 Bh.	....	1 13/32	1 7/32
¾ Straight	1 5/16	....	....
¾ x 1 Bh.	....	1 15/32	1 3/8
¾ x 1¼ Bh.	....	1 11/16	1 7/16
1 x ½ Red.	....	1 7/32	1 13/32
1 x ¾ Red.	....	1 3/8	1 15/32
1 Straight	1 17/32	....	....
1 x 1½ Bh.	....	1 7/8	1 21/32

NOTE: For all reducing (Red.) and bullhead (Bh.) tees the size of run is given first and the size of branch second. Fittings reducing on the run retain the same dimension as corresonding fittings without such reduction.

Above dimensions are subject to slight variation and are based on fittings as made by the Walworth Mfg. Co.

(*Continued on Data Sheet No.* 109-A.)

FITTINGS.

Standard Weight Cast-Iron Screwed Fittings.

125 Lbs. Working Pressure.

(Continued from Data Sheet No. 109.)

	A	L	W
In. Diam. In. Diam.	In. Diam.	In. Diam.	In. Diam.
3½ x 3 Red.			
3½ Straight	....	1 9/32	1 5/8
1¼ x 1½ Red.	....	1 7/16	1 11/16
1¼ x ¾ Red.	....	1 19/32	1 3/4
1¼ x 1 Red.	1 13/16	....	....
	....	1 15/15	1 7/8
1½ x ½ Red.	....	2 1/4	1 15/16
1½ x ¾ Red.			
1½ x 1 Red.	....	1 11/32	1 3/4
1½ x 1¼ Red.	....	1 1/2	1 13/16
1½ Straight	....	1 21/32	1 7/8
1½ x 2 Bh.	....	1 7/8	1 15/16
1½ x 2½ Bh.	2	....	....
	....	2 5/16	2 1/16
2 x ½ Red.	....	2 11/16	2 3/16
2 x ¾ Red.			
2 x 1 Red.	....	1 13/32	2 1/16
2 x 1¼ Red.	....	1 9/16	2 1/8
2 x 1½ Red.	....	1 23/32	2 3/16
2 Straight	....	1 15/16	2 1/4
2 x 2½ Bh.	....	2 1/16	2 5/16
2 x 3 Bh.	2 3/8	....	....
2½ x 1 Red.	....	2 3/4	2 1/2
2½ x 1¼ Red.	....	3 1/16	2 5/8
2½ x 1½ Red.	....	1 27/32	2 9/16
2½ x 2 Red.	....	2 1/16	2 5/8
2½ Straight	....	2 3/16	2 11/16
2½ x 3 Bh.	....	2 1/2	2 3/4
2½ x 3½ Bh.	2 7/8	....	....
2½ x 4 Bh.	....	3 3/16	3
	....	3 15/32	3 1/16
3 x 1 Red.	....	3 13/16	3 1/8
3 x 1¼ Red.			
3 x 1½ Red.	....	1 31/32	2 7/8
3 x 2 Red.	....	2 3/16	2 15/16
3 x 2½ Red.	....	2 5/16	3
3 Straight	....	2 5/8	3 1/16
3 x 3½ Bh.	....	3	3 3/16
3 x 4 Bh.	3 5/16	....	....
	....	3 19/32	3 3/8
3½ x 1½ Red.	....	3 15/16	3 7/16
3½ x 2 Red.			
1¼ x 2 Bh.	....	2 3/8	3 9/32
Run x Branch	....	2 11/16	3 11/32
3½ x 2½ Red.	....	3 1/16	3 15/32
1¼ Straight	....	3 3/8	3 19/32
1¼ x 1½ Bh.	3 21/32	....	....
3½ x 4 Bh.	....	4	3 23/32
4 x 1 Red.	....	2 3/32	3 1/2
4 x 1½ Red.	....	2 7/16	3 5/8
4 x 2 Red.	....	2 3/4	3 11/16
4 x 2½ Red.	....	3 1/8	3 13/16
4 x 3 Red.	....	3 7/16	3 15/16
4 x 3½ Red.	....	3 23/32	4
4 Straight	8 1/16	....	....
4 x 5 Bh.	....	4 19/32	4 1/8
4 x 6 Bh.	....	5 1/4	4 1/8

(Concluded on Data Sheet No. 109-B)

FITTINGS

Standard Weight Cast-Iron Screwed Fittings.

125 Lbs. Working Pressure.

(Concluded from Data Sheet No. 109-A.)

Run In. Diam.	x	Branch In. Diam.		A In. Diam.	L In. Diam.	W In. Diam.
5	x	1½	Red.	....	2 1/2	4 5/32
5	x	2	Red.	....	2 13/16	4 7/32
5	x	3	Red.	....	3 1/2	4 15/32
5	x	4	Red.	....	4 1/8	4 19/32
5 Straight				4 21/32	....	....
5	x	6	Bh.	....	5 5/16	4 21/32
6	x	2	Red.	....	2 13/16	4 7/8
6	x	3	Red.	....	3 1/2	5 1/8
6	x	4	Red.	....	4 1/8	5 1/4
6	x	5	Red.	....	4 23/32	5 5/16
6 Straight				5 5/16	....	....
6	x	8	Bh.	....	6 9/16	5 3/8

Run In. Diam.	x	Branch In. Diam.		A In. Diam.	L In. Diam.	W In. Diam.
7	x	4	Red.	....	4 3/16	5 15/16
7	x	5	Red.	....	4 23/32	6
7	x	6	Red.	....	5 3/8	6
7 Straight				6 1/16	....	....
8	x	2	Red.	....	2 7/8	6 1/8
8	x	4	Red.	....	4 3/16	6 1/2
8	x	6	Red.	....	5 3/8	6 9/16
8 Straight				6 13/16	....	....
10	x	4	Red.	....	4 1/8	7 11/16
10	x	6	Red.	....	5 5/16	7 3/4
10	x	8	Red.	....	6 9/16	7 13/16
10 Straight				8 1/4	....	....

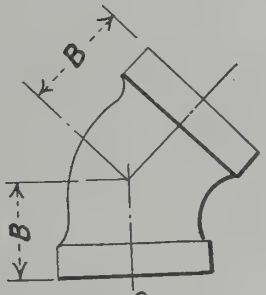
NOTE: For all reducing (Red.) and bullhead (Bh.) tees the size of run is given first and the size of branch second. Fittings reducing on the run retain the same dimension as corresponding fittings without such reduction.

Above dimensions are subject to slight variation and are based on fittings as made by the Walworth Mfg. Co.

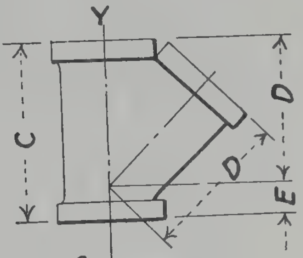
FITTINGS.

Standard Weight Cast-Iron Screwed Fittings.

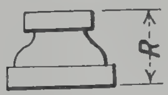
125 Lbs. Working Pressure.



45° Ell



45°-Y Reducer



Reducer

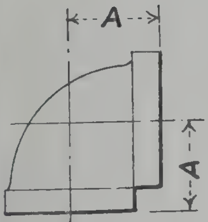
Size of Fitting In. Diam.	B	C	D	E	R
		Inches, Diam.			
1/4	3/4	....	....	....	....
3/8	13/16	....	....	....	....
1/2	7/8	2 1/2	1 7/8	5/8	....
3/4	1	3	2 1/4	3/4	....
1	1 1/8	3 1/2	2 3/4	3/4	....
1 1/4	1 5/16	4 1/4	3 1/4	1	....
1 1/2	1 7/16	4 7/8	3 13/16	1 1/16	....
2	1 11/16	5 3/4	4 1/2	1 1/4	....
2 1/2	1 15/16	6 1/4	5 3/16	1 1/16	....
3	2 3/16	7 7/8	6 1/8	1 3/4	2 15/16
3 1/2	2 3/8	8 7/8	6 7/8	2	3 1/8
4	2 5/8	9 3/4	7 5/8	2 1/8	3 3/8
4 1/2	2 13/16	11 5/8	9 1/4	2 3/8	3 5/8
5	3 1/16	11 5/8	9 1/4	2 3/8	3 7/8
6	3 7/16	13 7/16	10 3/4	2 11/16	4 3/8
7	3 7/8	15 1/4	12 1/4	3	4 13/16
8	4 1/4	16 15/16	13 5/8	3 5/16	5 1/4
9	4 11/16	20 11/16	16 3/4	3 15/16	5 11/16
10	5 3/16	20 11/16	16 3/4	3 15/16	6 3/16
12	6	24 1/8	19 5/8	4 1/2	7 1/8

Note: Y's reducing on the branch take same dimensions as straight fittings. Above dimensions subject to slight variations and based on fittings as made by Crane Co.

FITTINGS.

Extra-Heavy Cast-Iron Screwed Fittings.

250 lbs. Working Pressure



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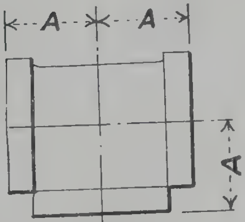
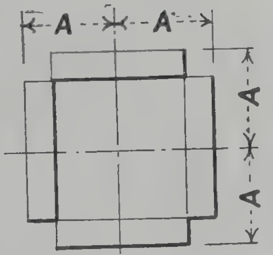


Tee



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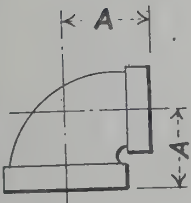
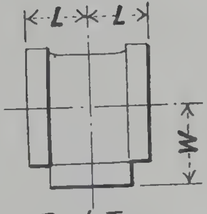
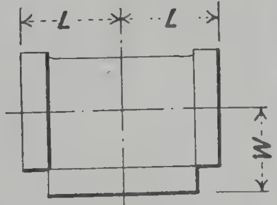


Red. Ell



Red. Tee



Bullhead Tee

Run In. Diam.	x	Branch In. Diam.		A In. Diam.	L In. Diam	W In. Diam.
½ Straight				1 5/32	....	....
½	x	¾	Bh.	....	1 25/64	1 21/64
½	x	1	Bh.	....	1 19/32	1 25/64
¾	x	½	Red.	....	1 21/64	1 23/64
¾ Straight				1 3/8	....	....
¾	x	1	Bh.	....	1 21/32	1 33/64
¾	x	1¼	Bh.	....	1 7/8	1 41/64
1	x	½	Red.	....	1 25/64	1 19/32
1	x	¾	Red.	....	1 33/64	1 21/32
1 Straight				**1 19/32**	....	....
1	x	1½	Bh.	....	2 3/32	1 29/32
1¼	x	½	Red.	....	1 33/64	1 13/16
1¼	x	¾	Red.	....	1 41/64	1 7/8
1¼	x	1	Red.	....	1 27/32	1 15/16
1¼ Straight				1 15/16	....	....
1¼	x	1½	Bh.	....	2 7/32	2 1/8
1¼	x	2	Bh.	....	2 9/16	2 1/4

NOTE—For all reducing (Red.) and bullhead (Bh.) tees size of run is given first and size of branch second. Fittings reducing on the run retain the same dimensions as corresponding fittings without such reduction.

Above dimensions subject to slight variation and based on fittings as made by Walworth Mfg. Co.

(Continued on Data Sheet No. 109-E)

FITTINGS.

Extra-Heavy Cast-Iron Screwed Fittings.

250 lbs. Working Pressure

(Continued from Data Sheet No. 109-D)

Run In. Diam.	x	Branch In. Diam.		A In. Diam.	L In. Diam	W In. Diam.
1½	x	½	Red.	....	1 35/64	1 31/32
1½	x	¾	Red.	....	1 45/64	2 1/32
1½	x	1	Red.	....	1 29/32	2 3/32
1½	x	1¼	Red.	....	2 1/8	2 7/32
1½	Straight			2 1/16	....	....
1½	x	2	Bh.	....	2 5/8	2 13/32
1½	x	2½	Bh.	....	3 1/32	2 17/32
2	x	½	Red.	....	1 45/64	2 5/16
2	x	¾	Red.	....	1 53/64	2 3/8
2	x	1	Red.	....	2 1/32	2 7/16
2	x	1¼	Red.	....	2 1/4	2 9/16
2	x	1½	Red.	....	2 13/32	2 5/8
2	Straight			2 1/2	....	....
2	x	2½	Bh.	....	3 5/32	2 1/8
2	x	3	Bh.	....	3 9/16	3 1/8
2½	x	1	Red.	....	2 5/32	2 27/32
2½	x	1¼	Red.	....	2 3/8	2 31/32
2½	x	1½	Red.	....	2 17/32	3 1/32
2½	x	2	Red.	....	2 7/8	3 5/32
2½	Straight			3	....	....
2½	x	3	Bh.	....	3 11/16	3 17/32
2½	x	3½	Bh.	....	4	3 19/32
2½	x	4	Bh.	....	4 13/32	3 23/32
3	x	1	Red.	....	2 13/32	3 1/4
3	x	1¼	Red.	....	2 7/8	3 3/8
3	x	1½	Red.	....	2 25/32	3 7/16
3	x	2	Red.	....	3 1/8	3 9/16
3	x	2½	Red.	....	3 17/32	3 11/16
3	Straight			3 11/16	....	....
3	x	3½	Bh.	....	4 1/4	4
3	x	4	Bh.	....	4 21/32	4 1/8
3½	x	1½	Red.	....	2 27/32	3 3/4
3½	x	2	Red.	....	3 3/16	3 7/8
3½	x	2½	Red.	....	3 19/32	4
3½	x	3	Red.	....	4	4 1/4
3½	Straight			4 1/32	....	....
3½	x	4	Bh.	....	4 23/32	4 7/16
4	x	1	Red.	....	2 19/32	3 31/32
4	x	1½	Red.	....	2 29/32	4 5/32
4	x	2	Red.	....	3 5/16	4 9/32
4	x	2½	Red.	....	3 23/32	4 13/32
4	x	3	Red.	....	4 1/8	4 21/32
4	x	3½	Red.	....	4 7/16	4 23/32
4	Straight			4 15/32	....	....
4	x	5	Bh.	....	5 13/32	5 3/32
4	x	6	Bh.	....	6 3/32	5 5/32

(Concluded on Data Sheet No. 109-F)

FITTINGS.

Extra-Heavy Cast-Iron Screwed Fittings.

250 lbs. Working Pressure

(Concluded from Data Sheet No. 109-E)

Run In. Diam.	x	Branch In. Diam.		A In. Diam.	L In. Diam	W In. Diam.
5	x	1½	Red.	....	3 7/32	4 23/32
4	x	2	Red.	....	3 9/16	4 27/32
5	x	3	Red.	....	4 3/8	5 7/32
5	x	4	Red.	....	5 3/32	5 15/32
5	Straight			6 11/32	....	....
5	x	6	Bh.	....	6 11/32	5 23/32
6	x	2	Red.	....	3 5/8	5 17/32
6	x	3	Red.	....	4 7/16	5 27/32
6	x	4	Red.	....	5 5/32	6 3/32
6	x	5	Red.	....	5 23/32	6 11/32
6	Straight			5 13/16	....	....
6	x	8	Bh.	....	7 17/32	6 17/32
8	x	2	Red.	....	3 3/4	6 21/32
8	x	4	Red.	....	5 9/32	7 7/32
8	x	6	Red.	....	6 17/32	7 17/32
8	Straight			7 3/16	....	....

NOTE—For all reducing (Red.) and bullhead (Bh.) tees size of run is given first and the size of branch second. Fittings reducing on the run retain the same dimensions as corresponding fittings without such reduction.

Above dimensions subject to slight variation and based on fittings as made by Walworth Mfg. Co.

PIPE COVERING.

General.

Pipe covering is usually constructed of fire-proof and insulating material moulded in proper form to fit the outside diameter of the pipe and split through the middle so as to allow placing on the pipe. The outside of the covering is generally jacketed with canvas, which (after the covering has been opened out, placed on the pipe and re-closed) is pasted across the joint so as to permanently hold the covering on the pipe. The chief materials used for pipe covering consist of asbestos, magnesia, hair felt, wool felt, cork, etc. Section covering can be secured for all standard pipe sizes from ½ in. to 10 in., inclusive, and for pipes of larger diameter, sheets and blocks are used, sectional covering not being at present manufactured for larger sizes.

One common grade of covering is built up of layers of thin felt made of asbestos fibre and particles of a finely ground spongy material, these layers being made in laminated form, and not in the moulded manner. In this particular type of insulation, the covering is cut on one side only, and is sprung apart when being placed on the pipe. It is furnished in 3-ft. sections with canvas covering on the outside and lacquered brass bands. This particular type of covering is made from ½ in. to 3 in. in thickness and in sheets and blocks 2 ft. x 3 ft. in size, and ½ in. to 4 in. in thickness.

Magnesia covering is usually composed of 85 per cent magnesia and is of the moulded type, being split so as to allow placing on the pipe. This insulation is commercially carried in thicknesses of "Standard" (which is approximately 1 in. thick) 1½ in., 2 in., double thick, and 3 in. thick, the sections being 3 ft. long and canvas-jacketed with brass lacquered bands. Blocks of 85 per cent magnesia are also obtainable in sizes 3 in. x 18 in. or 6 in. x 36 in. in thickness of 1 in. to 4 in.

Still another very common type of pipe insulation is known as Asbestocel, this being built with alternate layers of plain and corrugated asbestos felt, made up in cylindrical form so that the air cells formed by the corrugation run down the pipe and not longitudinally. Other forms are made where the air cells run longitudinally with the pipe instead of around the pipe. This covering is made in thickness of ½ in. ¾ in., "Standard," 1½ in., 2 in., double thick and 3 in.; in 3 ft. sections, canvassed with lacquered brass bands, and is also purchased in sheets and blocks, the sheets being 3 ft. square and the blocks 6 in. x 36 in., the thickness varying from ¼ in. to 4 in. Air-cell sectional pipe covering is constructed of layers of plain and corrugated asbestos paper; the air cells in this covering run longitudinally with the pipe. This covering is made ½ in., ¾ in., "Standard 1½ in., 2 in., double thick and 3 in. in 3 ft. sections, canvassed with brass lacquered bands, and can be purchased in sheets 3 ft. square and blocks 6 in. x 36 in., thickness running from ¼ in. to 4 in.

For warm water pipes and for the prevention of freezing, hair-felt and wool-felt covering is often used. Cork coverings are also much in vogue on refrigeration systems and drinking water lines. One type of anti-sweat pipe covering is built up of alternate layers of asbestos (water proofed) and insulating felts, held together by wire stitching; this is made in 3 ft. sections with brass lacquered bands of ½ in., ¾ in., and 1 in. thicknesses.

For refrigeration insulating, such as brine and ammonia pipes, a special sectional pipe insulation is often used, this being constructed of several layers of insulating felt, each layer being protected by an asphaltum water-proofing membrane applied between the pipe and felt and between each successive layer of felt. This results in each layer being practically hermetically sealed from the adjacent layer.

Where only the danger of freezing is encountered zero sectional piping insulation can be substituted, this being built up of several layers of insulating felt and lined on the inside with 1-in. thickness of hair felt. This covering is made in 3 ft. lengths split on one side, but comes in only one thickness, approximately 1¼ in.

Asbestos sheet mill board can be secured in standard sizes of 40 in. x 40 in., x 42 in. x 44 in. and thicknesses as follows:

1/32 in., 3/64 in., 1/16 in., 5/64 in., 3/32 in., ⅛ in., 5/32 in., 3/16 in., ¼ in.,
5/16 in., ⅜ in., and ½ in.

For covering fittings and eccentric surfaces plastic is generally used. This may be an asbestic plastic sometimes mixed with a certain percentage of plaster of paris to give a desired hardening effect, and sometimes consisting of 85 per cent magnesia combined with other materials.

PIPE COVERING.

Weights, Etc.

As a general thing, plastic comes in 100-lb. bags and will cover 25 to 30 sq. ft. of surface 1 in. thick. Approximate weights of covering run as follows:

Weight in pounds per 3-ft. length of sectional pipe coverings is shown in Table 1.

TABLE I.—WEIGHTS OF SECTIONAL PIPE COVERINGS.

A = Asbestos-sponge felted, 1 in. thick.
B = Asbestos fire-felt, 1 in. thick.
C = Magnesia, standard thickness.
D = Asbestocel, 1 in. thick.

	Weight in Pounds per 3-Ft. Length				Approximate Number of Ft. of Covering per Case
Size, In. Diam	A	B	C	D	
½	4	2¼	2¼	3	420
¾	4½	2¾	2½	3½	396
1	5	3	2¾	4	348
1¼	6	3½	3½	4½	291
1½	7	4	4¼	5	243
2	8	5	4½	6	183
2½	8½	6	5½	7	141
3	9	7	6¾	8	108
3½	10	8½	7½	8½	90
4	11½	9	8½	9	75
4½	13	9½	10½	9½	69
5	14½	10	12¼	10	54
6	16	12½	13¾	11	42
7	17½	13¾	15½	12½	36
8	19	15¾	18	15	27
9	20	16½	21	16	18
10	24	18	24	17½	15
12	33	21	33	20	12

Sponge-felted sheets 2 in. x 3 ft. weight 2½ lbs. per square foot.

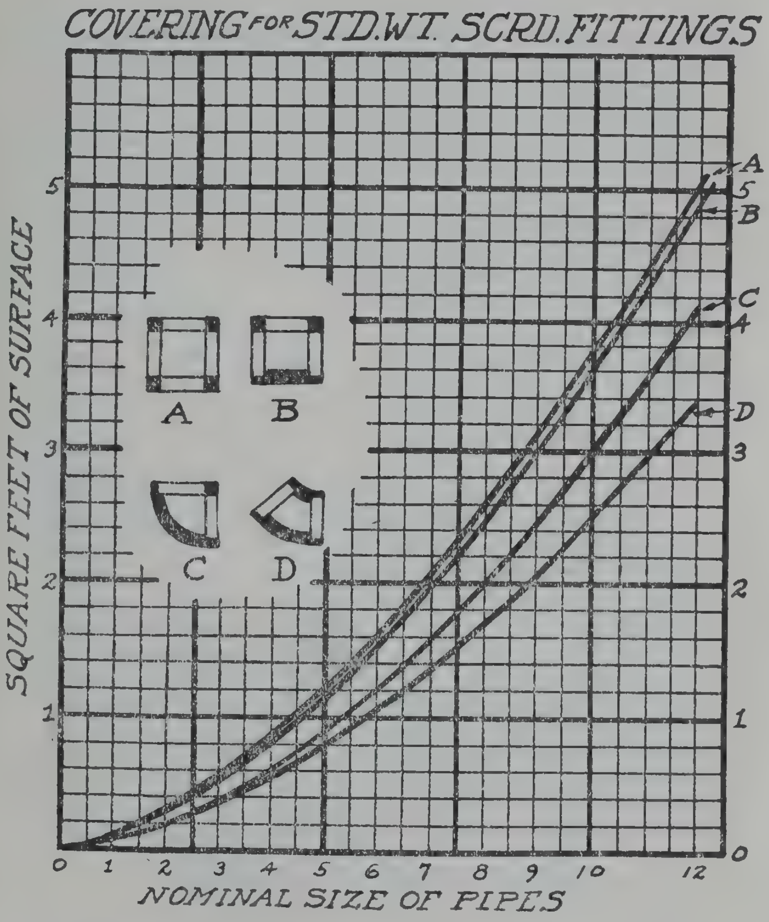
Asbestos fire-felt 1½ lbs. per square foot 85 per cent magnesia blocks 1½ lbs. per square foot. All of the above are assumed to be 1 in. thick.

Corrugated asbestos paper comes in rolls 36 in. wide, each roll containing approximately 250 sq. ft. One roll of one-ply about ¼-in. thick weighs 70 lbs.

Mineral wool weighs about 12 lbs. per cubic foot and is shipped in 60-lb. bags.

PIPE COVERING.

Covering for Standard-Weight Screwed Fittings.

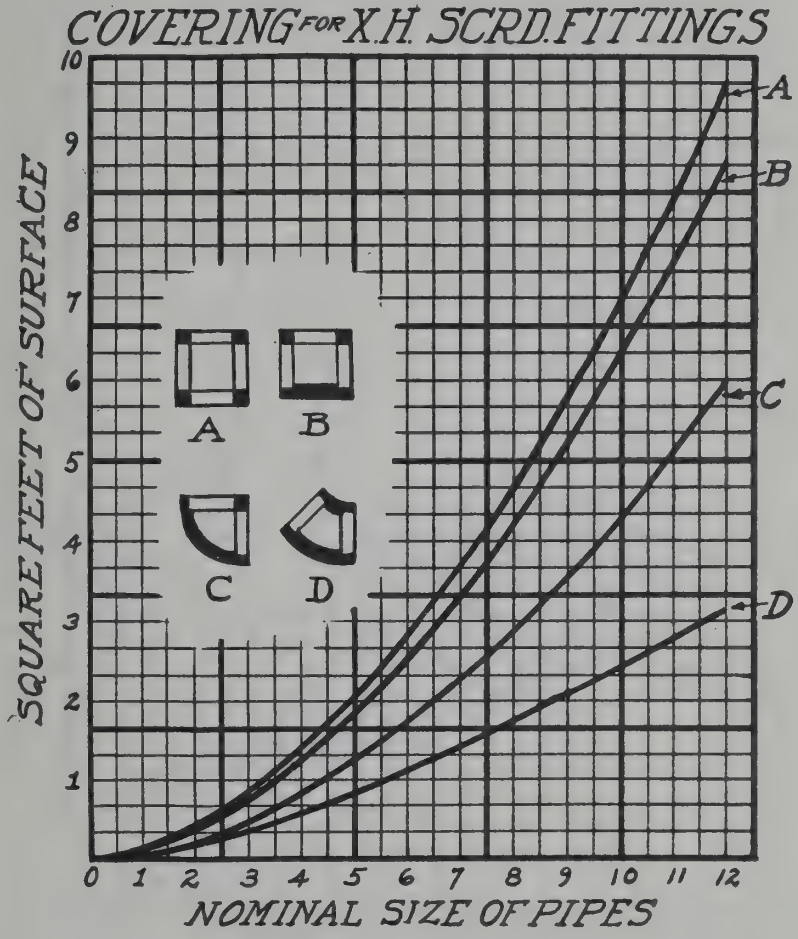


Where standard-weight screwed fittings are used on lines it is customary to cover them with plastic asbestos, and, as stated on standard data sheet No. 110-A, this plastic usually covers 25 to 30 sq. ft. of surface 1 in. thick for every 100 lbs. In order to ascertain the approximate surface on various fittings, the curves shown in Fig. 1 have been plotted, A being the curve for a cross; B for an ordinary T; C for a 90° elbow; and D for a 45° elbow. The amount of surface can be read at the left directly from the curve at a point vertically above the normal size of pipe, as noted along the bottom. For instance nine 4-in. elbows would have a surface of 0.6 x. 9, or 5.04 sq. ft. and would require:

$\frac{5.4}{30} \times 100$, or approximately 18 lbs. of plastic for 1-in. thick covering.

PIPE COVERING.

Covering for Extra-Heavy Screwed Fittings.

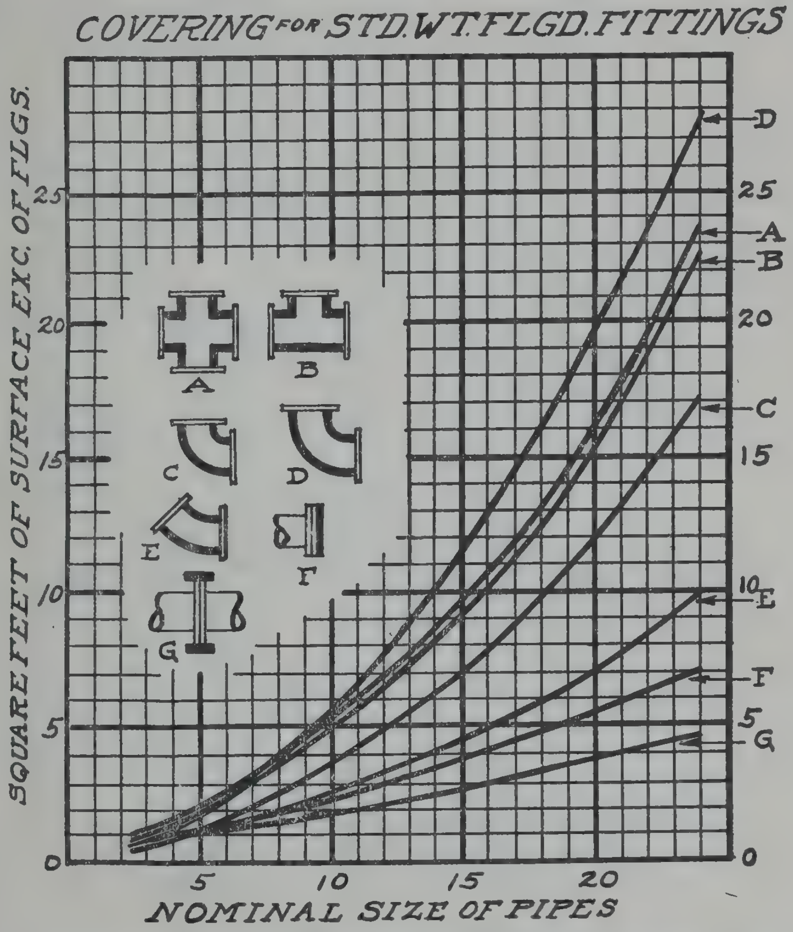


Where extra-heavy screwed fittings are used on lines it is customary to cover them with plastic asbestos, and, as stated on standard data sheet No. 110-A, this plastic usually covers 25 to 30 sq. ft. of surface 1 in. thick for every 100 lbs. In order to ascertain the approximate surface on various fittings, the curves shown in Fig. 1 have been plotted, A being the curve for a cross; B for an ordinary T; C for a 90° elbow; and D for a 45° elbow. The amount of surface can be read at the left directly from the curve at a point vertically above the nominal size of pipe, as noted along the bottom, for instance:

Nine 4-in. elbows would have a surface of $\frac{0.83 \times 9}{30} \times 100$, or approximately 24.9 lbs. of plastic for 1-in. thick covering.

PIPE COVERING.

Covering for Standard-Weight Flanged Fittings.



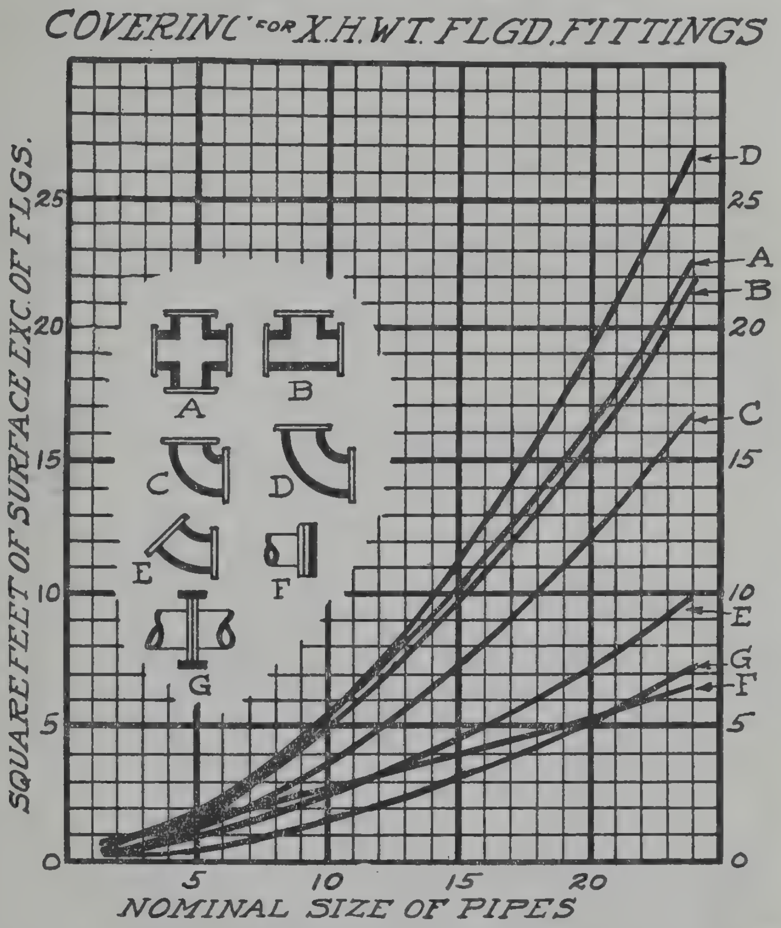
Where standard-weight flanged fittings are used on lines it is customary to cover them with plastic asbestos and, as stated on standard data sheet No. 110-A, this plastic usually covers 25 to 30 sq. ft. of surface 1 in. thick for every 100 lbs. In order to ascertain the approximate surface on various fittings, the curves shown in Fig. 1 have been plotted, A being the curve for a flanged cross; B for an ordinary flanged T; and C for a 90° flanged elbow; D for a long radius flanged elbow; E for a 45° flanged elbow; F for a blank flange on the end of the line and G for the covering around the pair of flanges as shown in the illustration. The amount of surface can be read at the left directly from the curve at a point vertically above the nominal size of pipe, as noted along the bottom. For instance nine 12-in. elbows would require for the body

$$\frac{5 \times 9}{30} \times 100 \text{ or approximately 150 lbs. of plastic}$$

for 1-in. thick covering, and the blank flange on the end of the line will have 3½ sq. ft. and the pair of flanges for the 12-in. line will have 2 sq. ft. all of which amounts can be reduced to pounds by dividing by 30 and multiplying by 100 for 1 in. thickness, while if ½-in. thickness is used, the area is divided by 60 and multiplied by 100 and for 2-in. thickness the quantity required for 1 in. is simply doubled which, while not strictly accurate, is sufficiently close for all purposes.

PIPE COVERING.

Covering for Extra-Heavy Flanged Fittings.



Where extra-heavy flanged fittings are used on lines it is customary to cover them with plastic asbestos and, as stated on standard data sheet No. 110-A, this plastic usually covers 25 to 30 sq. ft. of surface 1 in. thick for every 100 lbs. In order to ascertain the approximate surface on various fittings the curves shown in Fig. 1 have been plotted, A being the curve for a flanged cross; B for an ordinary flanged T; and C for a 90° flanged elbow; D for a long-radius flanged elbow; E for a 45° flanged elbow; F for a blank flange on the end of the line; and G for the covering around the pair of flanges, as shown in the illustration. The amount of surface can be read at the left directly from the curve at a point vertically above the nominal size of pipe as noted along the bottom. For instance nine 12-in. elbows would be required for the body

$$\frac{5 \times 9}{30} \times 100, \text{ or approximately 150 lbs. of plastic}$$

for 1-in. thick covering, and the blank flange on the end of the line will have 3½ sq. ft. and the pair of flanges for the 12-in. line will have 2 sq. ft. all of which amounts can be reduced to pounds by dividing by 30 and multiplying by 100 for 1-in. thickness, while if ½ in. thickness is used the area is divided by 60 and multiplied by 100, and for 2 in. thickness the quantity required for 1 in. is simply doubled which, while not strictly accurate, is sufficiently close for all purposes.

CAPACITY OF STEAM MAINS IN SQUARE FEET OF EQUIVALENT DIRECT RADIATION.

For a Total Pressure Drop of ⅛ Lb.

Size of Pipe, In. Diam.	Length of Run. Feet 100	200	300	400	500	750	1000	1250	1500	Size of Pipe In. Diam.
	Square Feet of Equivalent Direct Radiation									
¾	28	20	16	—	—	—	—	—	—	¾
1	63	46	36	32	28	22	20	18	—	1
1¼	116	83	68	59	50	43	37	33	30	1¼
1½	194	137	108	94	86	71	61	55	51	1½
2	427	316	264	228	207	175	147	130	123	2
2½	745	510	425	360	338	282	240	210	193	2½
3	1350	950	710	660	587	482	440	420	350	3
3½	1930	1370	1110	955	880	702	632	560	510	3½
4	2700	1900	1560	1340	1210	985	880	775	720	4
4½	3620	2550	2080	1790	1620	1315	1160	1050	965	4½
5	4800	3410	2790	2400	2170	1755	1560	1405	1280	5
6	7725	5460	4500	3850	3400	2825	2530	2250	2040	6
7	11250	8100	6550	5600	5000	4075	3580	3300	2930	7
8	15800	11250	9150	7875	7020	5700	4775	4425	4220	8
9	21100	15450	11950	10550	9500	7250	6600	5900	5475	9
10	28100	20400	16350	14050	12650	10250	8950	8100	7375	10
12	45600	31600	25750	22300	20000	16150	13900	12700	11800	12
14	59750	42200	33300	28800	25600	20700	18100	16500	15000	14
15	70210	49400	40000	34100	30500	24900	21400	19400	17900	15
16	83750	59750	49250	42500	37900	29900	26600	24000	21800	16
18	113500	93500	652 0	56250	50500	41400	35800	32000	29500	18
20	140000	100000	81000	70200	63250	51250	44250	40500	36500	20

CAPACITY OF STEAM MAINS IN SQUARE FEET OF EQUIVALENT DIRECT RADIATION.

For a Total Pressure Drop of ¼ Lb.

Size of Pipe, In. Diam.	Length of Run. Feet. 100	200	300	400	500	750	1000	1250	1500	2000	3000	3500	Size of Pipe, In. Diam.
	Square Feet of Equivalent Direct Radiation.												
¾	40	29	23	20									¾
1	90	66	52	46	40	31	29	26					1
1¼	167	118	97	84	75	61	53	47	43	38	29	22	1¼
1½	277	195	154	133	123	101	87	79	72	62	54	51	1½
2	609	450	375	325	295	250	210	185	175	150	133	124	2
2½	1060	725	600	525	480	400	340	300	275	245	211	195	2½
3	1925	1350	1100	940	850	700	625	600	500	430	383	353	3
3½	2750	1950	1575	1360	1250	1000	900	800	725	625	555	512	3½
4	3850	2725	2225	1910	1725	1400	1250	1100	1025	875	775	725	4
4½	5160	3625	2960	2550	2300	1875	1650	1500	1375	1175	1025	975	4½
5	6840	4850	3975	3410	3090	2500	2225	2000	1825	1600	1375	1280	5
6	11000	7775	6400	5475	4850	4025	3600	3200	2900	2540	2225	2025	6
7	16000	11500	9325	7960	7100	5800	5100	4700	4175	3660	3200	2975	7
8	22500	16000	13000	11200	10000	8100	6800	6300	6000	5100	4574	4400	8
9	30000	22000	17000	15000	19500	11000	9400	8400	7800	6850	6050	5500	9
10	40000	29000	23300	20000	18000	14600	12700	11500	10500	9120	8071	7358	10
12	63000	45000	36750	31810	28400	23000	19700	18100	16800	16200	12800	11500	12
14	85000	60000	47400	41000	36500	29500	25800	23500	21400	18600	16500	15000	14
15	100000	70400	57000	49100	43500	35500	30500	27700	25500	22000	19700	17800	15
16	119000	85000	70000	60500	54000	43600	37900	34200	31000	27000	24300	22000	16
18	160000	114000	93000	80000	72000	59000	51000	45500	42000	36300	32200	29600	18
20	200000	142000	115000	100000	90000	73000	63000	57700	52000	45300	40250	36600	20

CAPACITY OF STEAM MAINS IN SQUARE FEET OF EQUIVALENT DIRECT RADIATION.

For a Total Pressure Drop of ½ Lb.

Length of Run. Feet.

Square Feet of Equivalent Direct Raditions.

Size of Pipe, In. Diam.	100	200	300	400	500	750	1000	1250	1500	Size of Pipe, In. Diam.
¾	56	40	32							¾
1	126	92	72	64	56	44	40	36		1
1¼	232	166	136	118	100	86	74	66	60	1¼
1½	388	274	216	188	172	142	122	110	102	1½
2	854	632	528	456	414	350	294	260	246	2
2½	1490	1020	850	720	676	564	480	420	386	2½
3	2700	1900	1420	1320	1174	964	880	840	700	3
3½	3860	2740	2200	1910	1760	1404	1264	1120	1020	3½
4	5400	3800	3120	2680	2420	1970	1760	1550	1440	4
4½	7240	5100	4160	3580	3240	2630	2320	2100	1930	4½
5	9600	6820	5580	4800	4340	3510	3120	2810	2560	5
6	15450	10920	9000	7700	6800	5650	5060	4500	4080	6
7	22500	16200	13100	11200	10000	8150	7160	6600	5860	7
8	31600	22500	18300	15750	14040	11400	9550	8850	8440	8
9	42200	30900	23900	21100	19000	14500	13200	11800	10950	9
10	56200	40800	32700	28100	25300	20500	17900	16200	14750	10
12	91200	63200	51500	44600	40000	32300	27800	25400	23600	12
14	119500	84400	66600	57600	51200	41400	36200	33000	30000	14
15	140420	98800	80000	68200	61000	49800	42800	38800	35800	15
16	167500	119500	98500	85000	75800	59800	53200	48000	43600	16
18	227000	187000	130500	112500	101000	82800	71600	64000	59000	18
20	280000	200000	162000	140400	126600	102500	88500	81000	73000	20

CAPACITY OF STEAM MAINS IN SQUARE FEET OF EQUIVALENT DIRECT RADIATION.

For a Total Pressure Drop of 1 Lb.

Square Feet of Equivalent Direct Radiation.

Size of Pipe In. Diam.	100	200	300	400	500	750	1000	1250	1500	Size of Pipe In. Diam.
¾	80	58	46	40						¾
1	180	132	104	92	80	62	58	52		1
1¼	334	236	194	168	150	122	106	94	86	1¼
1½	554	390	308	266	246	202	174	158	144	1½
2	1218	900	750	650	590	500	420	370	350	2
2½	2120	1450	1200	1050	960	800	680	600	550	2½
3	3850	2700	2200	1880	1700	1400	1250	1200	1000	3
3½	5500	3900	3150	2720	2500	2000	1800	1600	1450	3½
4	7700	5450	4450	3820	3450	2800	2500	2200	2050	4
4½	10320	7250	5920	5100	4600	3750	3300	3000	2750	4½
5	13660	9700	7950	6820	6180	5000	4450	4000	3650	5
6	22000	15550	12800	10950	9700	8050	7200	6400	5800	6
7	32000	23000	18650	15920	14200	11600	10200	9400	8350	7
8	45000	32000	26000	22400	20000	16200	13600	12600	12000	8
9	60000	44000	34000	30000	27000	22000	18800	16800	15600	9
10	80000	58000	46600	40000	36000	29200	25400	23000	21000	10
12	126000	90000	73500	63620	56800	46000	39400	36200	33600	12
14	170000	120000	94800	82000	73000	59000	51600	47000	42800	14
15	200000	140800	114000	98200	87000	71000	61000	55400	51000	15
16	238000	170000	140000	121000	108000	87200	75800	68400	62000	16
18	320000	228000	186000	160000	144000	118000	102000	91000	84000	18
20	400000	284000	230000	200000	180000	146000	126000	115700	104000	20

SIZES OF STEAM PIPES.

E. D. R.	Steam Mains.		Steam Risers.	
in Sq. Ft.	One-Pipe In. Diam.	Two-Pipe In. Diam.	One-Pipe In. Diam.	Two-Pipe In. Diam.
30	1½	1¼	1¼	1¼
100	2	1½	1½	1½
150	2	1½	2	1½
200	2½	2	2½	2
250	2½	2	2½	2
300	3	2½	3	2½
400	3½	3	3	2½
500	3½	3	3	3
600	3½	3½		
800	4	3½		
1000	4½	4		
1500	5	4		
2000	5	4½		
3000	6	5		
4000	7	6		
6000	8	7		

(Harrison Safety Boiler Works)

SIZES OF RETURN MAINS.

The following table is based on a drop of 1 oz. in pressure in 100 feet of straight pipe. The percentage of steam is governed by the percentage of return pipe surface compared to the surface supplied by the supply main. Thus, if the total surface of the return line is 10% of the combined surface of the supply line, radiators and return line, then 10% of the steam carried by the supply main will pass through the radiators and out into the return main where it will be condensed. Under this condition the return main will have to carry the return condensation *and* 10% of the steam as well. The size of the wet return is obtained by taking the steam rating and comparing the square roots of the densities of the steam at atmosphere and the water, the result showing that the density of the water is about 1600 times as great and $\sqrt{1600} = 40$ the comparative capacity of the wet return. Thus, a 2-in. steam main carrying 300 sq. ft. of radiation at 1 oz. drop per 100 ft. of straight pipe will carry as a wet return, *with the same drop*, 300 x 40 = 12000 sq. ft. The steam capacity is, therefore, 12½% of the wet return capacity and if the return must carry, in addition to the condensation, say, 2½% additional steam, its capacity would only be one-half as much, or 300 ÷ 5% = 6000 sq. ft., etc.

There is much room for argument as to the correctness of the above assumption and there is certainly much more vapor in a vacuum return than allowed for in this table, this increase being due to re-evaporization of the return under the lower pressure. Some engineers figure the vacuum return at 15% steam, a gravity dry return at 10% steam and a gravity wet return as given in the table, plus two pipe sizes for corrosion and sediment.

TABLE I.

Sizes of Steam and Return Pipes.

(1 oz. Drop per 100 ft. Straight Pipe.)

S Size In. Diam.	A Steam Rating	B Wet Return	C 2½% Steam	D 5% Steam	E 7½% Steam	F 10% Steam	G 15% Steam	H 20% Steam
½	5	200	100	67	50	40	27	22
¾	20	800	400	270	200	160	114	88
1	40	1600	800	540	400	320	228	176
1¼	75	3000	1500	1012	750	600	427	330
1½	150	6000	3000	2024	1500	1200	855	660
2	300	12000	6000	4050	3000	2400	1710	1320
2½	500	20000	10000	6750	5000	4000	2850	2200
3	900	36000	18000	12150	9000	7200	5130	3960
3½	1500	60000	30000	20250	15000	12000	8550	6600
4	2000	80000	40000	27000	20000	16000	11400	8800
4½	2800	.....	56000	37800	28000	22400	15060	12320
5	3600	.....	.....	48600	36000	28800	20520	15840
6	6000	.....	.....	.....	60000	48000	34200	26400
7	9000	.....	.....	.....	.....	72000	51300	39600
8	13000	.....	.....	.....	.....	.....	74000	57200
9	18000	.....	.....	.....	.....	.....	.....	79200
10	23000	.....	.....	.....	.....	.....	.....	.....
12	37000	.....	.....	.....	.....	.....	.....	.....
14	55000	.....	.....	.....	.....	.....	.....	.....
16	78000	.....	.....	.....	.....	.....	.....	.....

Column "A," steam rating in equivalent square feet of direct radiation for piping within buildings for all classes of systems.

Column "B," rating for wet return main of a gravity system.

Column "C," rating for main return of the vacuum system.

Column "D," rating for the main return when it is above the water line in a wet-return gravity system.

Column "E," rating for the branch returns of the vacuum system, and for the branch returns that are above the water line in a wet-return gravity system.

Column "F," rating for the branch returns of a dry-return gravity system.

Columns "G" and "H," rating for gravity systems where the returns have unusual condensing capacity and for the returns in vacuum systems where jet water is used.

Column "S" is the nominal size of pipe diameter.

(J. A. Donnelly.)

SIZES OF RETURN MAINS.

In gravity systems the return pipe sizes will prove satisfactory if arranged as per the following table:

Size of Steam Main. In. Diam.	Corresponding Return Main. In. Diam.
1½	1¼
2	1½
2½	1½
3	2
3½	2½
4	2½
5	3
6	3½
8	4
10	4½
12	5

(Harrison Safety Boiler Works)

DIAMETER OF DRIP PIPES FOR STEAM MAINS.

Size of	Lenth of Steam Main Drained in Feet.			
In. Diam.	0-100	100-200	200-400	400-600
Steam Main	Diameter of Drip Pipe—Inches.			
2 or less	½	½	½	¾
2½ and 3	½	¾	¾	1
3½ and 4	¾	¾	1	1¼
4½ and 5	¾	1	1¼	1½
6	1	1¼	1½	1½

(Harrison Safety Boiler Works.)

Note.—We would recommend that no drip pipe be made less than 1 in. and certainly not less than ¾ in., reducing down to the trap size (if a trap is used) at the trap and enlarging immediately after leaving the trap discharge.

FLOW OF STEAM IN PIPES.

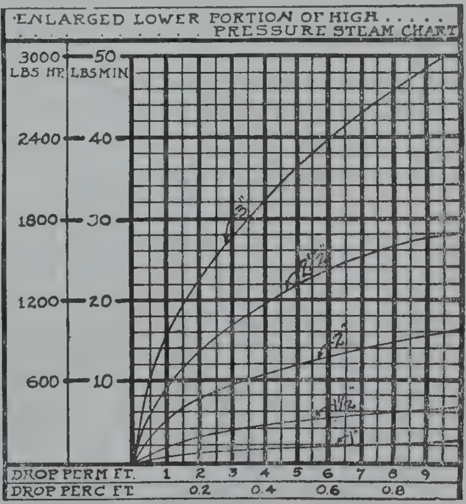
High Pressure Flow in Straight Pipes.

If 125 lbs. gauge or 140 lbs. absolute is taken as an average high pressure and a 100-ft. run as a basis of length, the curves shown in Data Sheet No. 128-J may be plotted for each size of pipe at various drops and 0 to 10 lbs. per 1000 ft. have been selected as covering all ordinary cases. It can be seen, however, that the drop is inversely proportional to the density—all other factors being the same—and that the delivery is directly proportional to the square root of the densities. From this relationship, the factors, given in Table 1, are derived for changing either the quantity or drop shown by the curves for 140 lbs. absolute pressure to any other absolute pressure.

Example: An 18-in. pipe, which, by the curves, delivers 5100 lbs. of steam per minute at 140 lbs. absolute pressure, with 7-lb. drop, will deliver at 90 lbs. absolute, 0.81 of 5100 lbs., or 4131 lbs. with the same drop, or would deliver 5100 lbs. with 1.52 x 7 lbs. = 6783 lbs. per minute with the same loss in pressure (7 lbs.) or will deliver 5100 lbs. with 7 x 0.57 = 3.99 lbs. drop in pressure.

TABLE 1.

Absolute Pressure in Pounds per Square Inch	Multiply Delivery by	or Multiply Drop by
250	1.33	0.57
220	1.24	0.65
200	1.19	0.71
180	1.13	0.79
150	1.03	0.94
140	1.00	1.00
130	0.97	1.07
120	0.93	1.16
100	0.85	1.38
90	0.81	1.52
80	0.77	1.70
70	0.72	1.93
60	0.67	2.22
50	0.62	2.65
40	0.56	3.26
30	0.48	4.27
20	0.40	6.23



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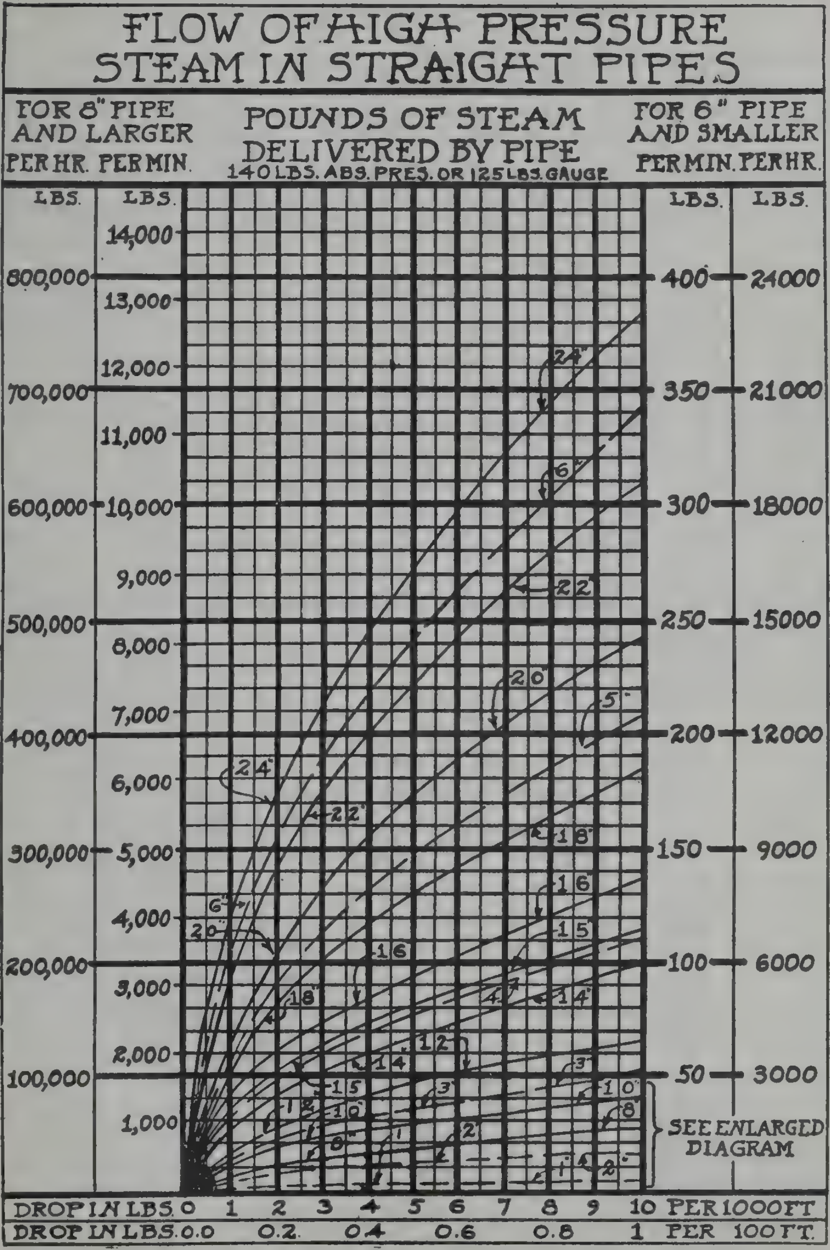


FLOW OF STEAM IN PIPES—High-Pressure Chart. No. 128-J.

FLOW OF STEAM IN PIPES.

Low Pressure Flow in Straight Pipes.

For steam at low pressure, say, 30 lbs. or less, the table prepared by Professor William Kent (Proceedings A. S. H. & V. E. 1907) may be taken as the most generally accepted means of determining the delivery and drop on such lines. From this table (Table 1) the curves shown in Fig. 1 have been plotted.

Table 1—Steam Delivery and Pressure Drop.

Nominal Pipe Size, In. Diam.	Initial Steam Pressure (Lbs. Gage)								
1/2	4.2	4.3	4.4	4.6	4.7	4.8	4.9	5.1	5.3
3/4	9.7	13.0	10.3	10.5	10.3	11.0	11.0	11.8	12.3
1	19.0	19.6	20.2	20.7	21.1	21.7	21.7	23.2	24.2
1 1/4	40.1	41.3	42.5	43.7	44.8	45.9	45.9	49.0	50.9
1 1/2	61.4	63.2	65.1	66.8	68.6	70.3	71.9	75.0	78.0
2	120.8	124.5	128.2	131.6	135.0	138.3	141.5	147.7	153.6
2 1/2	195.7	201.8	207.5	213.2	218.7	224.1	229.2	239.2	248.8
3	345.5	356.1	366.5	376.4	386.1	395.5	404.7	422.4	439.3
3 1/2	505.3	520.8	535.9	550.5	564.7	578.5	591.8	618.0	642.6
4	701.4	723.0	744.0	764.4	784.2	803.4	822.0	857.4	891.6
4 1/2	938.7	967.6	995.8	1023	1049	1075	1100	1148	1193
5	1252	1291	1328	1364	1399	1433	1467	1531	1592
6	2011	1074	2134	2192	2248	2303	2356	2459	2557
7	2936	3027	3115	3199	3281	3362	3440	3590	3733
	4082	4208	4331	4448	4564	4674	4783	4991	5191
89	5462	5630	5794	5951	6102	6252	6396	6678	6942
10	7314	7536	7758	7968	8172	8370	8562	8940	9296
12	11550	11916	12264	12594	12918	13236	13542	14136	14700

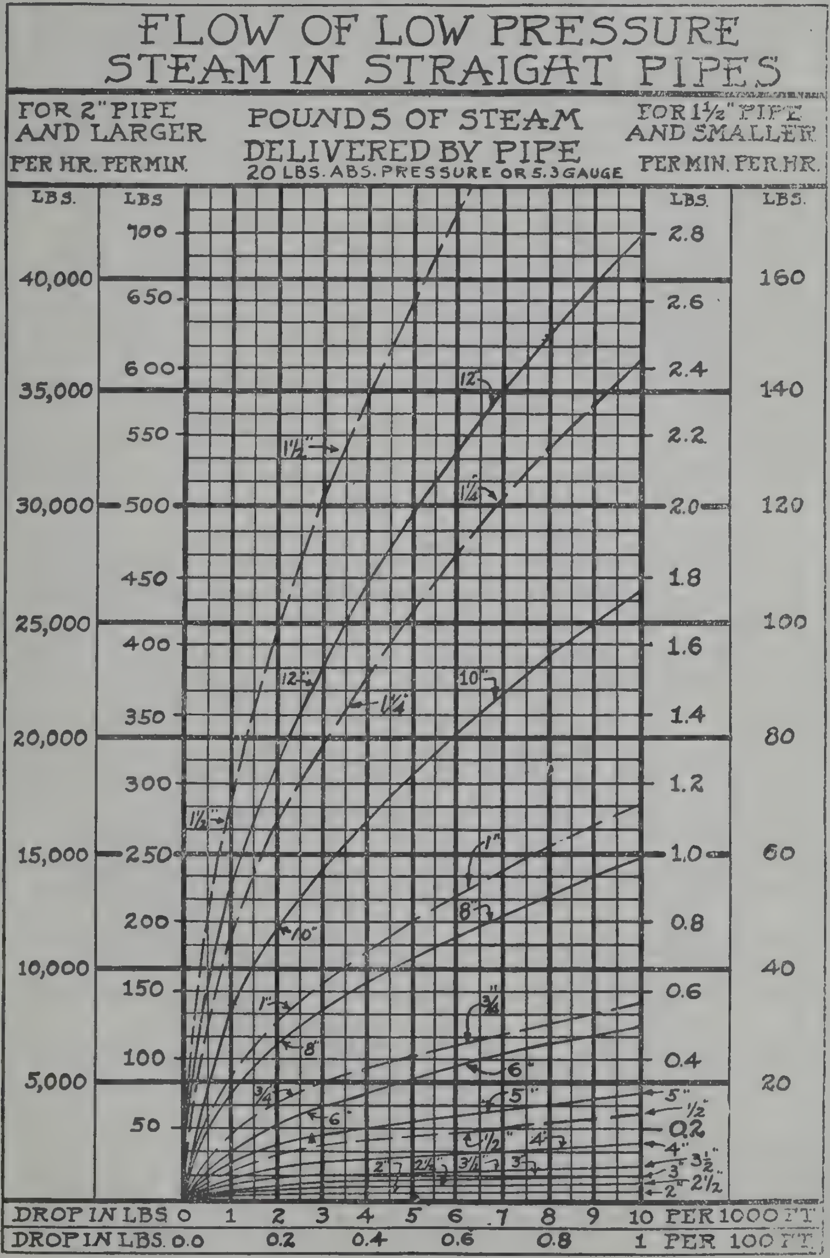
It will be seen that in plotting the curves some pressure had to be assumed as a basis and for this about 20 lbs. absolute, or 5.3 lbs. gauge was adopted, as this is the most commonly used low pressure. For any other pressure or drop, the factors are as given in Table 2.

Thus from the curves it can be seen that a 10-in. pipe at 5.3 lbs. gauge (20 lbs. absolute) and 0.6 lbs. drop per 100 ft. will deliver 333 lbs. of steam per minute, while at 1 lb. absolute pressure it will deliver 333 x 0.25 = 83 lbs. with the same drop, or 333 lbs. with 0.6 x 16.56 = 9.9 lbs. drop per 100 ft.

The foregoing does not take into account friction losses. To allow for each loss of pressure an arbitrary percentage may be added to the length of the line—usually 10% for fairly straight runs up to 25% for runs with numerous offsets. There is also a loss of energy encountered where the steam enters the pipe, this consisting of the pressure necessary to produce the velocity attained at the entrance and the pressure loss due to entering the pipe opening. This loss is usually considered as about the same as that obtained with a globe valve. The other large factor which must be considered is that of condensation. This depends on whether the pipe is bare or covered, the fact as to its being wet or dry and to the type and efficiency of the covering used.

TABLE 2.

Absolute Pressure in Pounds per Square Inch.	Multiply Delivery by	or Multiply Drop by
30	1.21	0.68
20	1.00	1.00
15	0.87	1.31
10	0.72	1.91
5	0.52	3.65
4	0.47	4.52
3	0.41	5.90
2	0.34	8.07
1	0.25	16.56



FLOW OF STEAM IN PIPES—Low Pressure Chart. No. 128-L.

FLOW OF STEAM IN PIPES

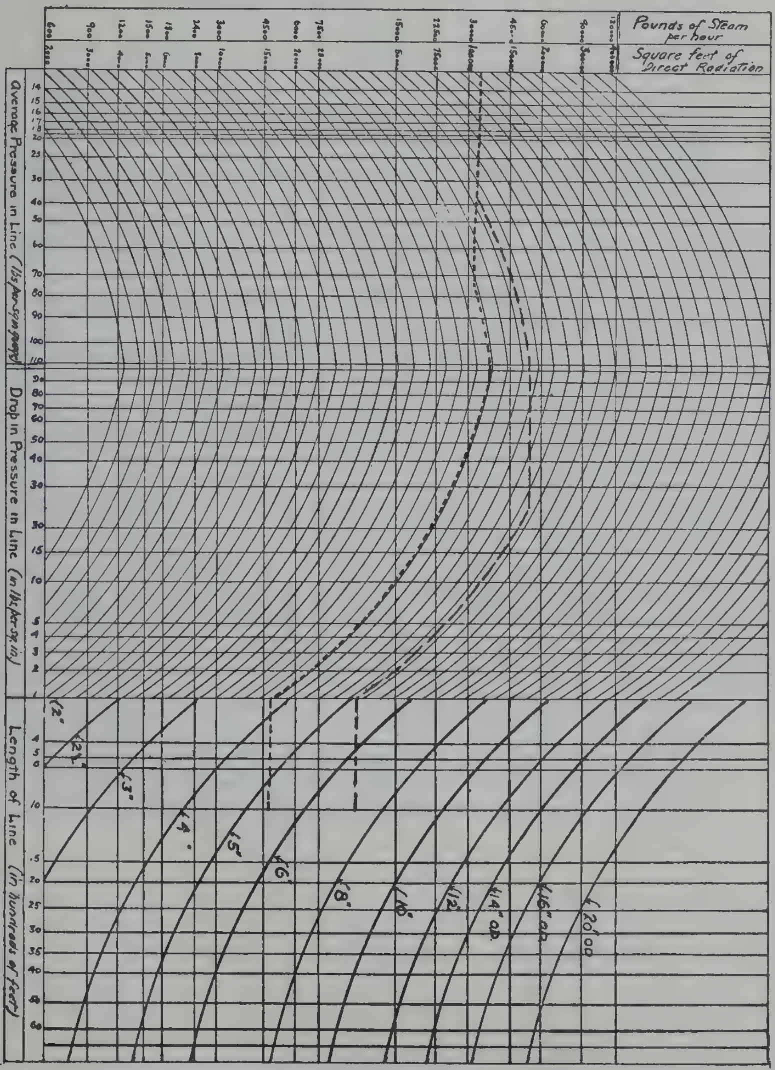
High-Pressure Distribution Systems

The accompanying chart is especially applicable to central station heating work. In using it, first obtain the amount of steam needed per hour as a peak requirement. Where close estimating is necessary, the diversity of the peak loads in the various locations should be considered. Then determine pipe sizes by the chart, using the drop in pressure allowable under the conditions.

Example: Take a line 1000 ft. long. Initial pressure, 50 lbs. Pressure at end of line, 25 lbs. Steam to be carried, 33,000 lbs. per hour. From the chart (see dotted line) an 8-in. pipe is required.

Assume the sam problem with 120 lbs. initial pressure. 30 lbs. at end of line. A 5-in. line will handle it.

(Curve derived from Babcock's formula).



From "Central Station Heating," by Byron T. Gifford.

ONE-PIPE GRAVITY STEAM SYSTEMS.

General.

The one-pipe system may be installed in several different ways and involves the use of only one control valve and one pipe connection to each radiator; automatic air valves are used for relieving air the same as on the ordinary two-pipe system. As far as labor is concerned, the increase of one pipe size in the steam supply does not produce an appreciable difference in work of installation and the added cost of the pipe is small; in exchange for this, all return valves, return risers and (to a greater or less extent) all return mains in the basement can be omitted, resulting in a considerable economy over the cost of a two-pipe job.

While not the most satisfactory method in operation, the true and complete one-pipe system throughout involves the use of a single steam main of enlarged size to accommodate the condensation in the bottom of the main, instead of a separate return pipe; the idea also assumes that the condensation will flow in a direction opposite to the flow of the steam which is, of course, not ideal. As a general rule, the smaller the quantity of water so flowing, the less will be the trouble resulting therefrom.

With the true one-pipe system throughout, the steam main, risers and branches all pitch back to a point near the boiler where the condensation is allowed to separate itself and to drop down under the water line, returning to the boiler through the regular return connection. Such a system is seldom used, except for small residences, owing to the large quantities of condensation bucking against the flow of steam in the mains, and the slight modifications necessary to eliminate this difficulty are almost invariably adopted for any work of importance.

ONE-PIPE GRAVITY STEAM SYSTEMS.

Circuit Main System.

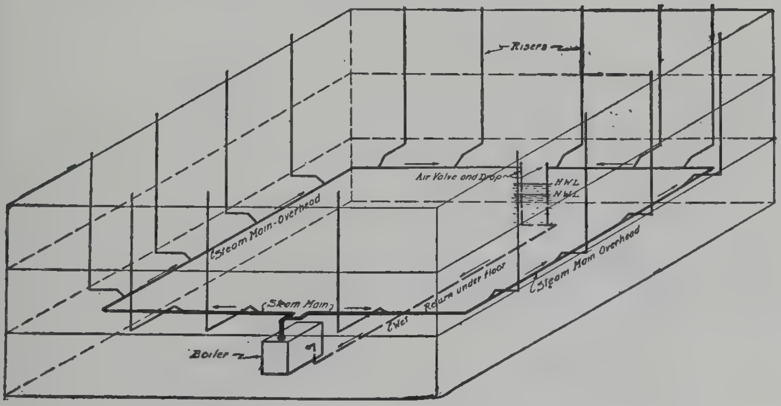


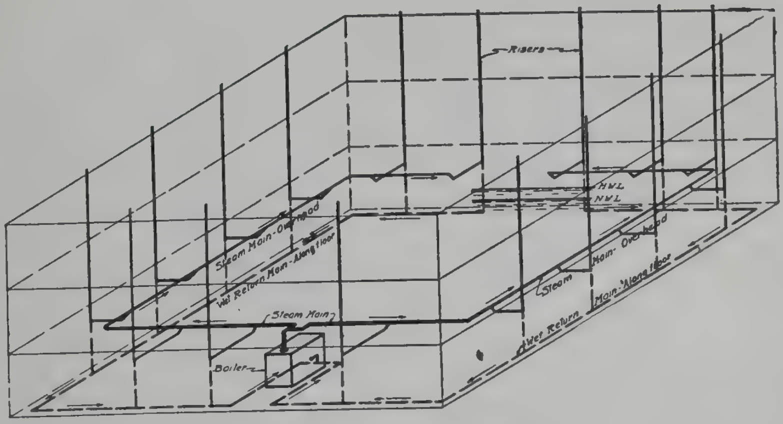
Fig 1.

To obviate the difficulty experienced with the true one-pipe system, what is known as the "circuit main" system has been used with great success. In this scheme, as shown in Fig. 1, the radiator runouts, risers and branches are left pitching down from the radiators and against the steam flow, but the steam main—the point of greatest trouble—is pitched with the flow of the steam so that the condensation flows along with the steam, instead of against it. At the end of the steam main run a drip pipe, or "bleeder," as it is commonly called, is dropped down below the water-line and carried back as a wet return. The pipes are pitched down in the direction indicated by the arrows and all pockets should be avoided by the use of eccentric fittings or flanges, while expansion must be properly cared for, both on the steam and return main and in the radiator connections to the risers.

It will be noted that, with the exception of the runouts and riser branches, all of the condensation flows with the steam and as long as the risers do not get too big, *i. e.,* have too much radiation placed on them so as to produce an excessive quantity of condensation flowing back down—there is no difficulty experienced with this piping arrangement.

ONE-PIPE GRAVITY STEAM SYSTEMS.

Relief System.

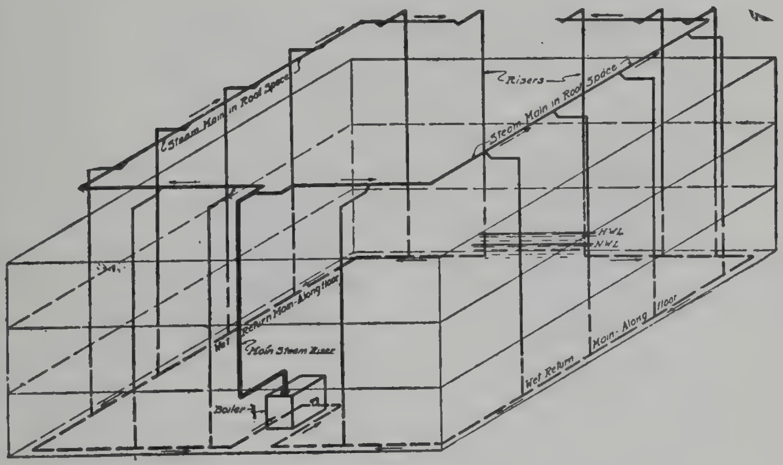


For larger jobs, where the area is considerable, but the height of the building low, a system termed the "one-pipe relief" system is used. This is shown in the illustration and consists of a steam main run around the basement ceiling, pitched with the flow of steam. Every riser in this scheme is dripped at the bottom and is supplied by a runout taken from the bottom of the steam main so as to drip the main at every riser connection. Thus the steam main does not carry any condensation from the radiators, and has its own condensation dripped at frequent intervals.

The return mains for the "one-pipe relief" system are usually run along the walls near the floor and as nearly under the risers as practical. The return should be a wet return, but if a dry return is absolutely necessary the drips should all be water-sealed before connecting thereto.

ONE-PIPE GRAVITY STEAM SYSTEMS.

Mills System.



THE MILLS SYSTEM

For jobs where the quantity of radiation goes up to say, over 600 sq. ft. per riser, it is better to use the overhead, or "Mills" system. This system and the "one-pipe relief" system more nearly approach a two-pipe job, having both steam main and a return main, but can be made in the one-pipe variety by using one radiator connection, with a single valve. A diagram of the well-known Mills system is shown herewith and it will be noted that all the steam is carried up one main riser to overhead mains run around the top of the building and pitched down from the main riser to the various drops. The drops have tees at the re-run around the top of the building and pitched down from the main at the top from the riser itself and from the radiators connected thereto, falls down through the drops—flowing with the steam all the way—and is finally drained off drips connected to the bottom of the drops and going to the main return—preferably a wet return, through which they find their way back to the boiler.

The Mills system establishes more nearly ideal conditions and should be used for higher building jobs, but is a more expensive system to install than either the "one-pipe circuit" or the "one-pipe relief." In spite of this it should be used for all larger work where the other two systems would be liable not to give satisfaction.

ONE-PIPE GRAVITY STEAM SYSTEMS.

Radiator Connections.

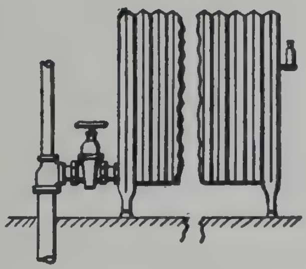


FIG. 1

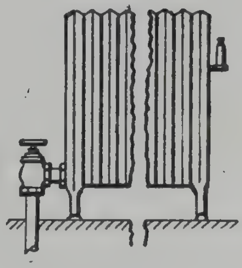


FIG. 2

A system which is theoretically correct, but wrong in small details, never gives satisfactory service any more than a system rightly installed in the details, but theoretically wrong in the general idea.

In all one-pipe work the steam connection to the radiator is practically the same; the connections must be made at the bottom and must be controlled (as shown in Figs. 1 and 2) by a gate valve or angle globe valve looking down, both of these points being determined by the necessity of accommodating the flow of the condensation out of the radiator. The automatic air valve should be placed on the opposite end of the radiator from the steam valve and about one-third to two-thirds of the height of the radiator above the bottom. The runouts, of course, must be arranged to provide for expansion in the riser.

ONE-PIPE GRAVITY STEAM SYSTEMS.

Radiator Runouts and Main Line Vents.

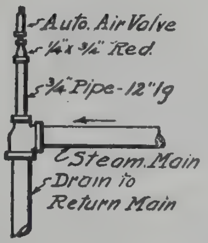


Fig. 1

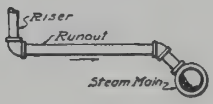


Fig 2.

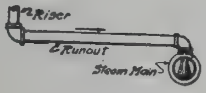


Fig. 3

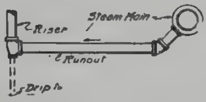


Fig. 4

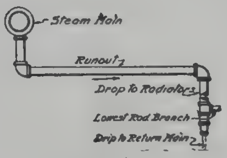


Fig. 5

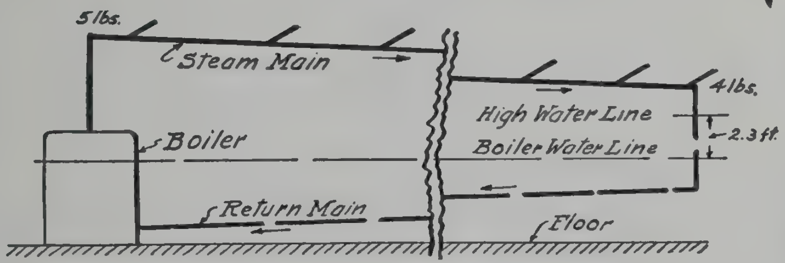
For the "circuit" system (See Fig. 1, Sheet No. 129-A) where the steam main drops down under the water line, an automatic air valve should be placed to relieve the air caught between the advancing steam and the water seal, when starting up the system. Otherwise, the air so pocketed will interfere with the return of the condensation and cause all sorts of hammering and trouble. Best results are obtained when the air valve is installed as shown in the detail, Fig. 1. In the "relief" and "Mills" systems (Sheets Nos. 129-B and 129-C), no such air valves are necessary, but are sometimes used at the end of the large steam main, merely as an aid to help relieve the air more quickly when starting up.

The steam runouts from the steam mains to the risers or radiators in a "circuit" system should be inclined down from the radiator or riser to the main and should enter the main at 45°, as shown in the detail drawing, Fig. 2, thus allowing the return condensation to flow along the bottom of the runout and down into the steam main without cutting across the path of the steam flow in the main. If the connection is made as shown in Fig. 3, the pouring into the steam main of the returning condensation is likely to interfere with the flow of steam therein.

The runouts for a "relief" system should be inclined in the opposite direction toward the drip connection at the base of the riser, as shown in the detail Fig. 4. It is practical to have these leave the main vertically downward, but the 45° connection is more popular. The runout from a steam main in the Mills system is generally arranged as shown in detail Fig. 5, and slopes toward the steam drops.

ONE-PIPE GRAVITY STEAM SYSTEMS.

Drop in Pressure and Rise of Return.



The accompany drawing illustrates a diagrammatic elevation of a one-pipe system, assuming a 1-lb. drop in the steam line between the boiler and the end of the line at times of maximum load. Thus, with 5 lbs. at the boiler and 1 lb. loss in the line the steam pressure at the far end of the line would be 4 lbs. The water in the wet return then has a pressure of 5 lbs. per square inch pressing down on its surface in the boiler and a pressure of only 4 lbs. per square inch pressing down on its surface in the vertical leg connecting with the steam main at the end of the run. This unbalanced pressure must equalize itself and does so by the water rising in the vertical leg until the vertical column of water in the leg counterbalances by its weight the difference between the two pressures; i. e., the pressure loss in the steam pipe.

This loss is here assumed arbitrarily as 1 lb. and since the weight of a vertical volume of water is 0.43 lbs. per square inch for every foot of height, the rise of the water, under the assumed conditions, will be 1 lb. ÷ 0.43, or 2.33 ft. As a general thing, it is customary to allow less pressure drop and to keep 18 or 24 in. between the normal water-line and the high water-line established when the system is in operation. In other words, the lowest point of the stream and the radiation is kept at least 24 to 30 in. above the water-line of the boiler. In the circuit, relief and Mills system shown in Data Sheets Nos. 129-A, 129-B and 129-C, the normal water-line (N. W. L.) and the high water-line (H. W. L.) is indicated at the point on the return connections farthest from the boiler.

The high water-line should always be calculated to keep at least 6 in. below the steam main or lowest level of radiation, so that, with 30 in. difference, the water rise could not be over 24 in., with 24 in. difference the rise could not be over 18 in., etc. If 1 lb. = 2.3-ft. rise, then 16 oz. = 2.3 x 12, or 28 in. and 1 oz. = 1.8-in. rise. This results in a table for allowable rise as follows:

Allowable Rise of Water in Return Mains, Inches.	Allowable Loss in Pressure in Steam Mains, Pounds.
3.5	⅛
7	¼
14	½
28	1
42	1½
56	2
70	2½
84	3

ONE-PIPE STEAM SYSTEMS.

Pipe Sizing.

The sizing of pipe of one-pipe mains may be based on an arbitrary rule such as $D = {}^1/_9 \sqrt{R}$ when

D is diameter of main in inches
R is the amount of radiation supplied

Or the tables given in Data Sheets 128-A, B, C, etc., may be used. Supposing a one-pipe system has a distance of 30-in. between the low end of the steam main and the normal boiler water-line. Then the permissible total drop in pressure is about one pound. If half of this loss occurs in the fittings and half in the pipe the pressure drop in the straight pipe must not exceed 1 lb. ÷ 2 or ½ lb. for the run which (if it is 200 ft. from the boiler to the end of the main) would require the use of the "Table for ½ lb. drop — 200 ft. run" (shown in Data Sheet No. 128-C).

Having determined the size of the steam main, the return main may be sized on the basis of Table I or on the capacities given for return lines of all systems as shown on Standard Data Sheet No. 128-F.

TABLE I.

Size of Steam Pipe, Diam. Inches	Dry Return Diam. Inches	Wet Return, Diam. Inches
1	1	¾
1¼	1	1
1½	1¼	1
2	1½	1¼
2½	2	1½
3	2½	2
4	3	2½
5	3	2½
6	4	3
8	4	3
10	5	4
12	6	5

Of course in using any table for sizing pipes the radiation should all be reduced to E. D. R., as explained in full in Standard Data Sheet No. 13, before obtaining sizes from the tables.

For cases where the condensation flows against the steam the table for ⅛ lb. drop (Standard Data Sheet No. 128-A) should be used and the pipe increased *one* pipe size. Dry returns on small lines are usually made one size less than the steam line supplying the same radiation, and large dry returns, two or three pipe sizes less (see Table I herewith).

ONE-PIPE STEAM SYSTEMS.

Riser Sizes.

For risers with steam flowing against the return from the radiators, as occurs in the "circuit" system and "relief" system, a velocity in the main of 10 ft. per second should not be exceeded. On this basis Table I should be used for up-feed risers.

TABLE I.

(Velocity of steam 10 ft. per second.)

Size of Pipe Diam. Inches	Sq. Ft. of Radiation (E. D. R.)
1	30
1¼	60
1½	80
2	130
2½	190
3	290
4	520

With down-feed, such as occurs with the Mills system, an increased velocity of 50% or more is allowable, as shown in Table II

TABLE II.

Down-Feed Drops.

(Velocity of Steam 15 ft. per second.)

Size of Pipe, Diam. Inches.	Sq. Ft. of Radiation, (E. D. R.).
1	50
1¼	90
1½	120
2	200
2½	290
3	340
4	800

Another authority sizes steam risers on a one-pipe system as shown in Table III.

TABLE III.

Nominal Size of Pipe Diam. Inches.	Up-Feed Riser. 5 stories.		Down-Feed Riser. 5 stories.	
		Over 5 stories.		Over 5 stories.
	Square Feet of Radiation.			
1	34	30	60	54
1¼	67	60	112	100
1½	100	90	162	146
2	200	180	260	234
2½	367	330	600	540
3	667	600	880	790
4	1333	1200	1600	1440

~~FLOW OF STEAM IN PIPES—Capacity of Steam Mains, ⅛ Lb. Drop.~~ No. 129-H.

ONE PIPE STEAM SYSTEMS— Riser Sizes

ONE-PIPE GRAVITY STEAM SYSTEMS.

Radiator Connections.

Table I.

Size of Pipe, Diam. Inches.	Square Feet of Radiation. (E. D. R.)
1	24 or less
1¼	24 to 60
1½	60 to 80
2	80 to 130

Table II.

	1-in.	1¼-in.	1½-in.	2-in.	3-in.	4-in.	5-in.	6-in.	8-in.	10-in.
Fitting.		Lineal Feet of Additional Length to be Added to Main								
90° Ell	3	4	5	7	10	13	17	20	27	33
Globe Valve	7	8	10	13	20	27	33	40	53	67
Entrance	5	6	8	10	15	20	25	30	40	50

Table III.

Radiation. Sq. Ft.	Main Size, Diam. Inches.	Runout and Riser, Diam. Inches.	Radiator Connections Diam. Inches.
24	1	1¼	1
60	1¼	1¼	1¼
125	1½	2	1½
250	2	2½	2
600	2½	3	..
800	3	4	..
1600	4	5	..
2300	5	..	..
4100	6	..	..
9600	8	..	..

Radiator connections should be not less than the sizes shown in Table I.

All horizontal branches over 5 ft. long should be one pipe size larger than the riser to which they connect. This is due to the flow of condensation through the horizontal pipe being retarded.

While it has been previously stated in this article that 25% is allowed as added to the actual length of the main to obtain an equivalent length for the fittings, sometimes the friction may increase 100% and when more accurate results are desired, the fittings, valves, etc., can be counted and the actual equivalent length computed. For this purpose the friction of each fitting and valve must be assumed as equivalent to an added length of run as shown in Table II.

A method which can easily be memorized is to allow 60 pipe diameters for the "entrance," each globe valve and each tee, where the steam passes through the branch, and 40 pipe diameters for each 90° ell; tees passed through on the run and gate valves may be neglected. The "entrance" friction is the friction occurring when the steam enters the pipe.

For small residence systems Table III previously published in THE HEATING AND VENTILATING MAGAZINE for April, 1908, will serve as a very complete schedule.

VACUUM HEATING SYSTEMS.

General.

The vacuum system of heating was primarily designed with the idea of reducing the back pressure on engines where the exhaust is used for heating, but the advantages soon became so manifest that vacuum systems were speedily adopted for all sorts of work regardless of the fact whether the steam is supplied by en engine exhaust or from some other entirely related source.

On the average vacuum systems of today very little vacuum exists except in the return line and (while it is possible for this vacuum to extend into the radiators when the steam is partially throttled down at the supply valve) the vacuum itself seldom, if ever, extends as far as the steam line. Indeed, many vacuum systems are supplied with steam through a reducing valve which keeps 5 lbs. or more steam pressure on the supply line at any and all times.

Therefore, a vacuum system may be defined as a steam heating system in which the radiator connection to the return line is trapped and where the air and water pass through the trap into the return line from which both are removed by the suction of a positive-acting piston pump.

The chief thing to be remembered in designing vacuum systems is that there must be no direct connection between the steam and return main either through drips, radiators or water seals; all connections between the two mains must have a trap interposed to prevent the inrush of steam into the return line.

Vacuum systems will operate with bottom connections and even with steam radiators, but the best results are attained when top-inlet water radiators are used in conjunction with graduated supply valves, as this allows a partial or graduated heating of the radiator *horizontally* instead of concentrating the heat in a few end sections, as otherwise results.

The quantity of radiation is not affected by use of a vacuum system over that required for gravity work (since the steam pressures are identical) and the radiation may be determined as explained in Standard Data Sheet No. 13. The chief advantage of the vacuum system over the gravity system, besides the graduation of the heat control, lies in the quickness with which the returns are sucked back by the vacuum pump and the corresponding reduction in pipe sizes on the return lines; air valves on the radiators are also eliminated.

The amount and type of radiation having been fixed upon the next factors to be considered consist of the sizes and arrangement of the pipe lines.

VACUUM HEATING SYSTEMS.

Pipe Sizing.

The sizing of the piping for a system of vacuum heating is not at all difficult when the tables included in Standard Data Sheets 128-A, B, C, etc. are used. The two factors to be decided upon consist of the length of run from the source of steam supply to the farthest and most remote radiator, counting in all vertical as well as all horizontal travel; this gives the lineal distance the steam will have to flow in the worst case. The drop is usually taken so as to leave the steam with not less than 1 lb. pressure at the farthest radiator (but is seldom figured as over 2 lbs. total) and as the drop shown in the tables is for straight pipe *only* it is customary to allow 100% increase for fittings, since many mains contain enough fittings to almost double the friction obtained in the straight pipe.

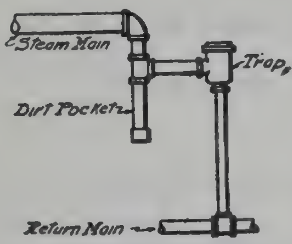
Thus, if 3 lbs. pressure of steam is generated and the farthest radiator must have 1 lb. at the radiator then the allowable drop is 3 — 1 = 2 lbs. Since the fittings absorb half the drop and the straight pipe the other half, each will cause a drop of 2/2 or 1 lb. And if the longest run is, say, 375 ft. the table for "Capacities of Steam Mains — 1 lb. drop and 400 ft. E. D. R." on Data Sheet 128-D would be used to size the steam lines.

For the return lines custom follows the sizes given in the table on Data Sheet 128-F for 15% steam, although the author of the table claims that 2½% steam on the mains, and 7½% on the branches would be sufficient. Owing to sediment, rust, etc., it is generally considered better practice to use the 15% capacities.

VACUUM HEATING SYSTEMS.

Piping Details.

Fig 1



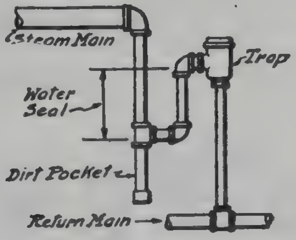
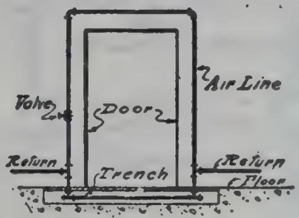


Fig 2

Fig 3



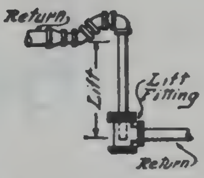


Fig 4

Having the proper schedules for sizing the lines the next thing is to arrange the lines properly. The steam main should slope down in the direction of flow with a drip on the end so as to allow the water and air (but not the steam) to pass off into the return line. Such main drips are usually connected up as shown in Fig. 1, with a scale pocket in front of the trap to prevent foreign particles finding lodgment in the trap. If the trap is one operating on the thermostatic principle it must be protected from the direct action of the steam and slugs of water (which sometimes shoot down the main)by a water seal, as shown in Fig. 2.

Where it is necessary to pass the return line under a door, an air loop may be run over the top of the door at the same time so the return main can be brought back to the same level on the other side. This is illustrated in Fig. 3, the water passing through the lower pipe and the air up and over the loop, both uniting again beyond the door without placing any additional load upon the pump.

If it is required to lift the return (a thing to be avoided if possible) a rise of moderate amount—say 4 or 5 ft.—may be accomplished without much difficulty. This raise may be all in at one point or may be divided into as many steps as desirable as long as the total lift does not exceed the allowable limits. In order to lift the return a special arrangement called a lift fitting is necessary, this being shown in Fig. 4 and described as follows:

A common flanged tee two sizes larger than the main return pipe is attached to the end of the return at the point of lift; into the top of this tee is screwed a pipe one size smaller than the main return, the end of this pipe being run down to a point ¼-in. below the level of the invert of the return. This results in the suction pulling up the water in preference to the air and in the sucking in of globules of air so that the water and air are intermixed. At the top the riser is carried slightly above the level of the higher main and is then turned over and connected into the higher main through two 45° ells, as shown; this prevents the slugs of water falling back down the vertical leg. The main is then increased to its former size and runs along from the new elevation the same as before.

VACUUM HEATING SYSTEMS.

Piping Details (Continued).

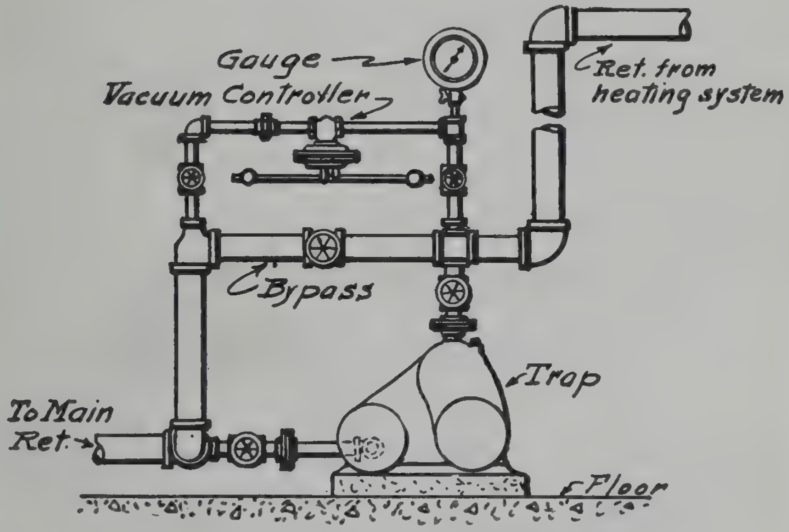


FIG 5.

Where several buildings are connected to a single return line, some near the vacuum pump and some more remote—or where one building has to employ a lift in the return and another does not—it may prove desirable to control the amount of vacuum carried on each building so as to equalize the effect. Thus the farthest building, or the one employing a lift, may receive the full effect of the vacuum, while the other buildings may be throttled down by means of a vacuum controller so as to have the vacuum applied to the radiators in every building approximately equal.

The vacuum controlled is primarily a combination trap and reversed reducing valve. The trap lets all the condensation pass and operates on the bucket or float principle, but the air and vapor pass through a special air-line by-pass controlled by a weighted diaphragm valve so as to open whenever the vacuum in the building line is too small to close whenever it rises up to the proper degree. Thus the controller automatically permits the removal of water at all times but prevents more vacuum than that desired from reaching the building radiators.

Fig. 5 shows how a typical piping connection for such a vacuum controller can be made.

VACUUM HEATING SYSTEMS.

Piping Details (Continued).

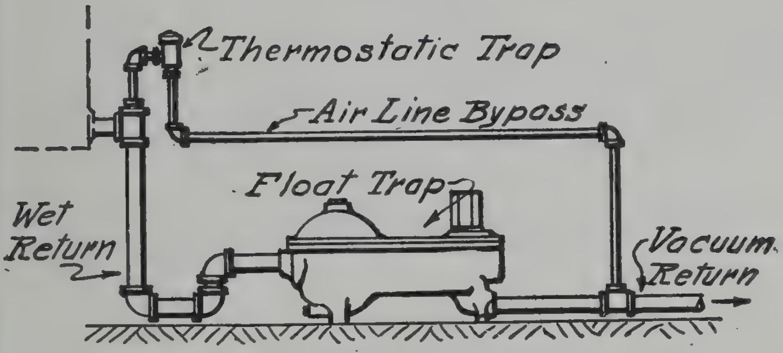


FIG 6.

Where large quantities of condensation are to be handled, together with comparatively small amounts of air, it is more economical to use a float or bucket trap to handle the water, and an auxiliary thermostatic trap to relieve the air. Such conditions are usually found in the draining of large mains and in fan blast heaters. For such cases the scheme shown in Fig. 6 is often used, the thermostatic trap handling what little air comes through the line and the water trap taking care of the condensation; in this way the use of a multitude of thermostatic traps is avoided.

VACUUM HEATING SYSTEMS.

Sizing the Vacuum Pump.

The vacuum pump is the heart of the vacuum system and the proper size of pump is often a question upon which an honest disagreement occurs. The simplest solution is the rule of thumb that the cubic displacement of the pump when operated at a reasonable piston speed—say, 80 to 100 ft. per minute—should be not less than ten times the volume of return water to be handled. This rule, however, seems to give smaller capacity pumps than good practice warrants and should be changed to fifteen times the volume.

For instance, a system having 20,000 sq. ft. E. D. R. would condense some 20,000 x ⅓ or 6,666 lbs. of water per hour, which is 111 cu. ft.; this is roughly 111/60 = 1.8 cu. ft. per minute. Therefore, the pump displacement should be 1.8 x 15 = 27 cu. ft. per minute. At 80 ft. per minute piston speed this would mean a cylinder area of 27 ÷ 80 = 0.34 sq. ft., or 0.34 x 144 = 49.16 sq. in. This is equivalent to an 8-in. diameter cylinder.

The United States Government uses a longer and more complex method evolved by Warren Webster & Co., and which consists of assigning each pump a "factor" rating and then calculating total factors in the system, allowing 100 for each vacuum trap and 1 for each square foot of E. D. R.; thus, for a system with 20,000 sq. ft. of direct radiation and 400 traps, the total factor would be (400 x 100) + (20,000 x 1) =

$$40{,}000 + 20{,}000 = 60{,}000$$

The pump schedule is shown in Table I and it will be seen that by this method an 8 in. x 10 in. x 14 in. pump would be required which is quite a little larger than the size obtained by the first method, unless the multiple of 15 is used.

TABLE I.

SINGLE-CYLINDER DOUBLE-ACTING VACUUM-PUMP FACTOR RATINGS.

Size of Pump, Inches	*Factor Rating*
4 x 4 x 5	6830
4 x 4 x 6	7270
4 x 4 x 8	8000
4 x 5 x 5	10680
4 x 5 x 6	11350
4 x 5 x 8	12500
4½ x 5½ x 8	15125
4½ x 6 x 5	15390
4½ x 6 x 7	17215
4½ x 6 x 8	18000
5 x 6 x 10	19390
7 x 7¼ x 10	28250
6 x 7½ x 12	30600
7 x 8 x 10	34410
6 x 8 x 12	36620
6 x 9 x 12	43627
8 x 9¼ x 12	48957
8 x 10 x 12	57220
8 x 10 x 14	60250
10 x 12 x 12	82397
10 x 10 x 16	90713
10 x 14 x 16	122500
12 x 14 x 20	133000
12 x 16 x 16	161270
14 x 16 x 20	173720
16 x 18 x 20	219870
16 x 18 x 14	233640
18 x 20 x 20	271440

VACUUM HEATING SYSTEMS.

Vacuum Pump Connections.

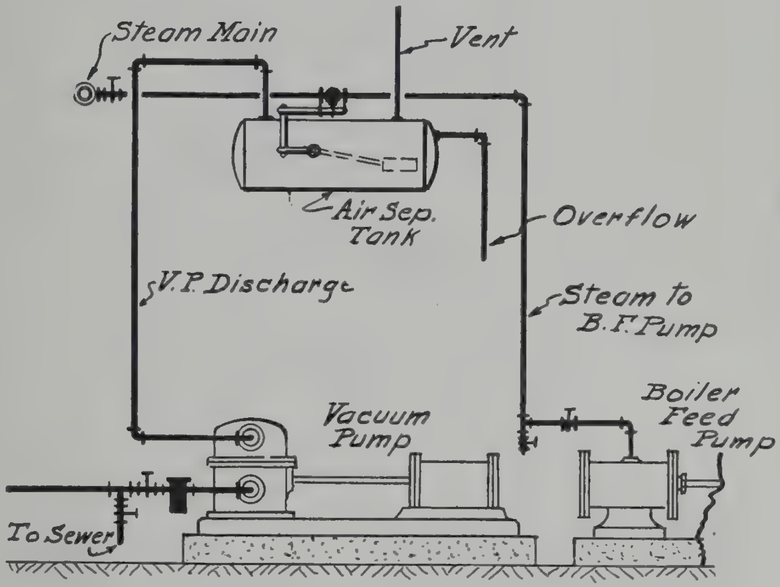


FIG 1.

It is not necessary or even advisable to use any sort of a receiving tank before a vacuum return enters the vacuum pump suction. The only thing necessary is to install a good strainer close to the pump, with a valve on the building side of the strainer and a bypass connection to the sewer; this is illustrated in Fig. 1. Sometimes a vapor condenser is installed in the return line with cold water inlet and outlet connections, the water circulating through interior tubes and condensing the vapor in the return line. In other instances a little cold water is added to the return itself in order to reduce its temperature to below the vaporizing point. Where such jet water is used it is generally introduced through the strainer which has a special tapping for this purpose.

On the pump discharge the air, vapor and water are driven through a check valve and up into an air separating tank in which a float is located, controlling the return pump which takes its suction from the tank, or else the outlet of the tank is connected to the feed-water heater through a deep water-seal, as shown in Fig. 1. The air passes off through the air vent on the air separating tank.

VACUUM PUMP CONNECTIONS.

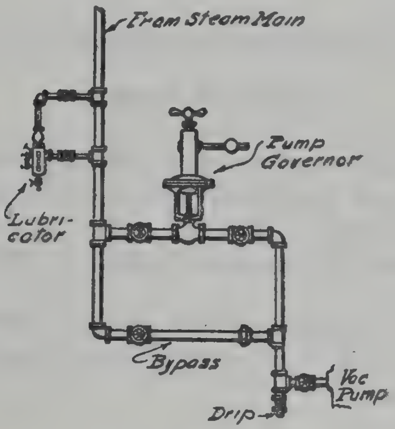


FIG. 1.

A vacuum pump, to produce the best results on a heating system, should maintain a vacuum of constant degree, the intensity of this vacuum being at all times under the immediate control of the engineer. In order to do this, some sort of automatic device is necessary.

The most satisfactory method so far developed is undoubtedly the scheme of inserting a pump governor in the steam line supplying the pump, as shown in Fig. 1, so that the pump will carry a constant vacuum on the suction line. This governor is operated by a small pipe (not shown) connected to the suction line, instead of to the discharge, as is the case with the regular pump-pressure regulator.

VACUUM HEATING SYSTEMS.

Radiator Connections.

Runouts connecting radiators to risers even in vacuum systems should never be less than ¾-in., even when the radiator return tapping is only ½-in.; when the runouts are over 5 ft. in length they should be made at least one size larger than the radiator tappings.

Direct radiator tappings, indirect radiator tappings and wall coils should be as follows, *based on E. D. R.,* and not on actual surface.

E. D. R. Square Feet	Condensation per Hour Lbs. of Water			Supply In.		Return In.
Up to 50	13	¾	Rad.	¾	Coil	½
Over 50 up to 100	25	¾	Rad.	1	Coil	½
Over 100 up to 150	38	¾	Rad.	1 ¼	Coil	½
Over 150 up to 175	44	1	Rad.	1 ¼	Coil	½
Over 175 up to 300	75	1	Rad.	1 ½	Coil	¾
Over 300 up to 632	158	—	—	2	Coil	¾
Over 632 up to 1100	275	—	—	2 ½	Coil	1

VACUUM HEATING SYSTEMS.

Radiator Connections.

Runouts connecting radiators to risers even in vacuum systems should never be less than ¾-in., even when the radiator return tapping is only ½-in.; when the runouts are over 5 ft. in length they should be made at least one size larger than the radiator tappings.

Direct radiator tappings, indirect radiator tappings and wall coils should be as follows, *based on E. D. R.*, and not on actual surface.

E. D. R. Square Feet	Condensation per Hour Lbs. of Water	Supply In.		Return In.
Up to 50	13	¾ Rad.	¾ Coil	½
Over 50 up to 100	25	¾ Rad.	1 Coil	½
Over 100 up to 150	38	¾ Rad.	1¼ Coil	½
Over 150 up to 175	44	1 Rad.	1¼ Coil	½
Over 175 up to 300	75	1 Rad.	1½ Coil	¾
Over 300 up to 632	158	— —	2 Coil	¾
Over 632 up to 1100	275	— —	2½ Coil	1

VAPOR HEATING

General.

NOTE.—*A vapor, vaccum, vapor-vacuum, vacuum-vapor, atmospheric, modulated or thermograde system of heating is considered as any system in which the steam pressure ordinarily carried is practically at atmosphere, or slightly below, or in which the returns are open to the atmosphere and where no pump or other positive mechanical device is employed to pull back the returns.*

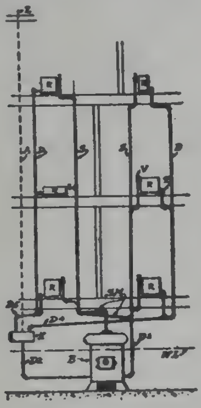


FIG. 1.

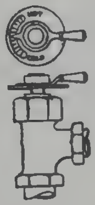


FIG. 2.

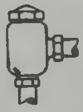


FIG. 3

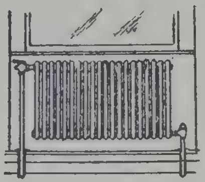


FIG. 4.

The vapor method of heating compares favorably both in economy and cost of installation with water. It responds quickly to increased or decreased draft, (i. e., it is easy to control) and possesses no large body of water which must be cooled or warmed in toto before a variation in the quantity of heat is obtained. During unseasonable warm days this system can be shut down and the radiators carried absolutely cold until such time as the outside temperature requirements may necessitate a re-opening of the drafts, and it absolutely avoids the danger of leaks from automatic air valves which is an item of considerable importance.

Referring to Fig. 1, the boiler B supplies steam to the steam main SM, this main supplying the steam risers S which may be either upfeed or downfeed, the radiators R shown being supplied by an upfeed system. The steam follows up the various risers to the graduated valves V on the radiators, these valves being the same as used on an ordinary vacuum system and having graduated control (so that certain portions of the radiator may be heated) such as ¼, ½, ¾ and full, as shown in plan and elevation, Fig. 2.

The steam enters the radiator through these valves and heats the proportion of surface approximately as indicated on the dial over which the pointer is placed.

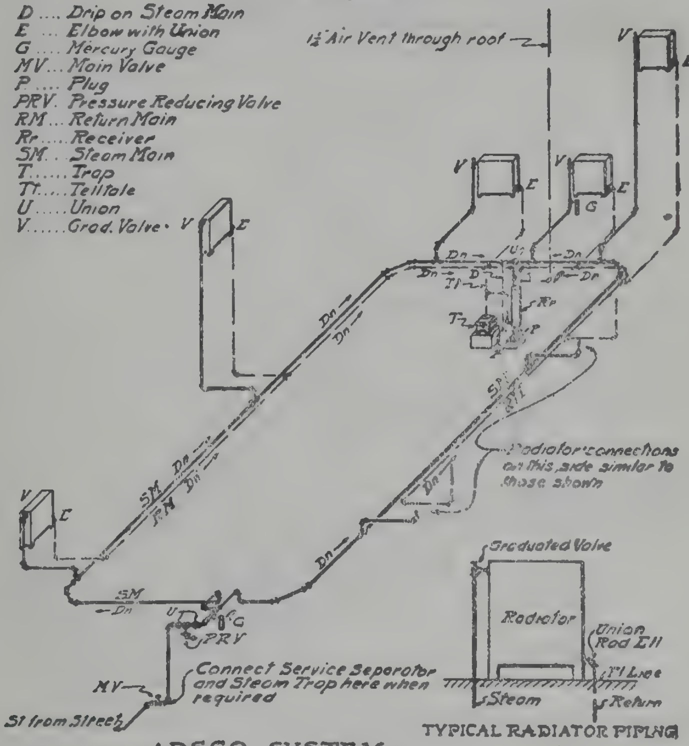
To permit the steam to enter the radiator it is necessary for it to force a certain amount of air out of the radiator, all of this air passing out through the return, there being no air valves on this system. Therefore, the return valves T are what are known as "air and water-relief" valves, as shown in Fig. 3, being identical with the return valves used for radiators on strictly vaccum systems. In fact any sort of a trap passing both air and water may be used for this purpose.

From this valve the air and water flow along the return main and into the tank X (Fig. 1) where the air relief line A leaves the top of the return tank X, this permitting the air to escape when it is caught between the return water and the water in the vertical boiler return pipe D-2. The air passes out through the vent pipe A which is carried through the roof at Z or to the atmosphere at some other convenient point. The condensation water then passes down through the boiler return pipe D-2 and enters the boiler B.

Where necessary to drip steam mains or low points of steam pipes on the radiator side of the return valve, drip lines must be installed and, in order to avoid a multiplicity of return valves, these drips are all connected into a horizontal line in the basement which is drained by a drip valve which discharges the water into the drip return D-4 or D-5, or with the boiler return D-2. Since the air finds its outlet entirely through the radiators it is not essential that the drip return be above the water-line, as the flooding of this pipe does not interfere with the air relief.

A typical radiator connection is shown in Fig. 4 and it will be noted that the radiators are the water type with a top connection on the supply side. This is not absolutely necessary but with leg radiators it is an advantage, making the graduated valves V more accessible than if they were located at the bottom of the radiator as is customary with ordinary gravity steam systems.

VAPOR HEATING.
Adsco System.



-ADSCO SYSTEM-

LAYOUT OF ADSCO SYSTEM WITH CENTRAL HEATING SERVICE.

The Adsco system of atmospheric steam heating has been developed and perfected by the American District Steam Co. of North Tonawanda, N. Y. This system was one of the first of the many so-called "vapor" systems to be evolved and as such has had the ample opportunity of a long period of years to be perfected and brought to a final state of development.

The piping system as designed to suit central heating conditions is shown in the typical layout given in Fig. 1.

The steam when coming from the street is usually supplied at a pressure varying from 2 to 10 lbs. and the special reducing valve is arranged to reduce and maintain on the system a pressure sufficient to give 5 oz. at the radiator valves. The sizes of reducing valve recommended are two pipe sizes less than the diameter of the low-pressure-main; thus, a building requiring a 6-in. low-pressure main would be supplied by a 4-in. street connection and 4-in., or 4x6-in., reducing valve. The schedule of sizes recommended for 2 to 15 lbs. street pressure is as follows:

Radiation. Sq. Ft.	Size of Reducing Valve. Inches.
0 to 200	1 x 1½
200 to 300	1¼ x 2
300 to 600	1½ x 2½
600 to 900	2 x 3
900 to 1400	2½ x 3½
1400 to 2200	3 x 4
2200 to 2800	3 x 5
2800 to 3600	4 x 5
3600 to 6000	4 x 6
6000 to 8500	5 x 7
8500 to 11000	5 x 8

Straight valves with both inlet and outlet of the small size can also be used if desired.

(To Be Continued)

VAPOR HEATING.

The Adsco System.

(Continued from Data Sheet No. 132-A.)

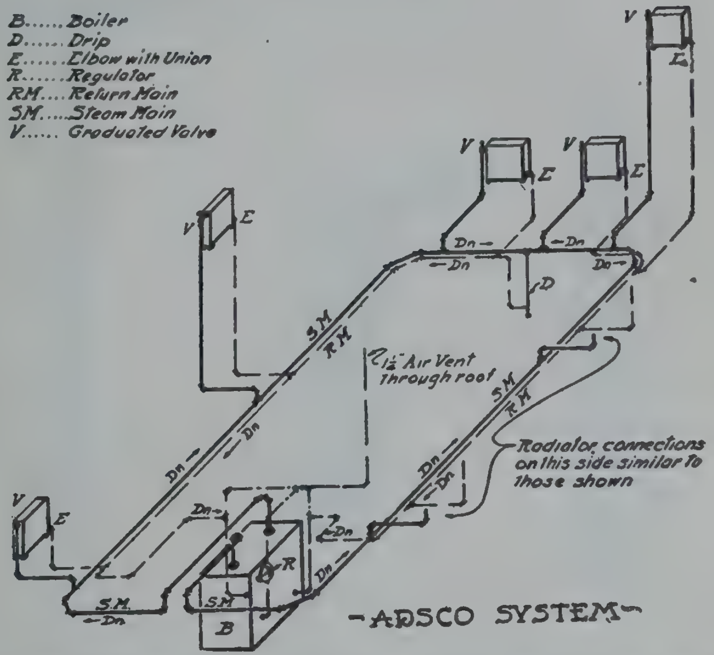


FIG. 2—ARRANGEMENT OF ADSCO SYSTEM WITH INDEDENDENT BOILER.

If a steam boiler is used the piping should be run as shown in Fig. 2 and the boiler load will only be 80% of the total radiation, plus the steam main loss (not over 10%), making the total required boiler capacity 90% of the total radiation; to control the boiler pressure a special regulator is used, this being illustrated in Fig. 3. It consists of a weighted float which rises on the surface of the water inside of the vented regulator. This float is connected to a lever operating the draft and check dampers. The creation of any pressure in the boiler backs the water into the regulator and raises its water-line, thus operating the float. The safety valve used on the boiler is set to relieve at 15 oz. pressure but can readily be adjusted down to 11 oz. if desired; its tapping is 1¼-in. size.

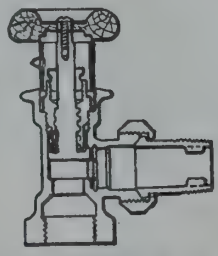


FIG. 2-A—CONSTRUCTION OF ADSCO VALVE.

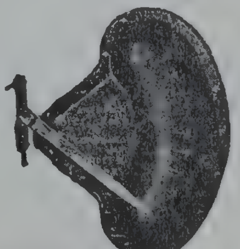


FIG. 3—SPECIAL BOILER PRESSURE REGULATOR.

(Concluded on Data Sheet No. 132-C.)

VAPOR HEATING.

The Adsco System.

(Concluded from Data Sheet No. 132-B.)

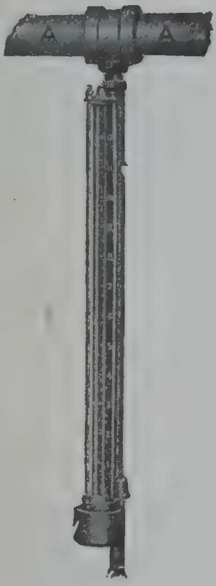


FIG. 4—WATER GUAGE.

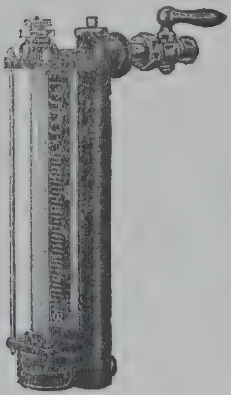


FIG. 5—MERCURY GUAGE.

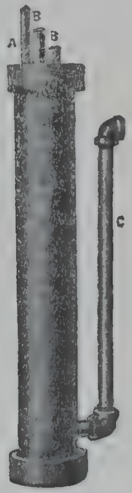


FIG. 6—PIPE RECEIVER.

To accurately register the small amounts of pressure generated either the water gauge illustrated in Fig. 4 or the mercury gauge shown in Fig. 5 may be used. The water gauge is generally used on district heating systems but the mercury gauge may be applied to either.

The steam main in the basement should be arranged so as to secure the best circulation and with the minimum drop in pressure. In all changes of direction on the main, bends, long sweep or 45 deg. fittings should be used, and the size of the steam main should at no point be decreased below 1½-in.

The steam is carried in the steam main up to a point within four feet of the graduated radiator valve; at this point the radiator branch is reduced to ¾-in. in size as all radiator valves have ¾-in. thread. The interior construction of the valve is illustrated in Fig. 2-A, and it is designed to supply a given radiator with 80% of the amount of steam it can condense under ordinary operating conditions and with 5 oz. of steam pressure on the supply pipe to the valve; the proper size of radiator is stamped on the valve top and the valves are made with stampings in multiples of 5 from 10 sq. ft. to 200 sq. ft.; for this reason the size of the radiator must always be specified in ordering valves.

The radiators used are common cast-iron surface, of water pattern.

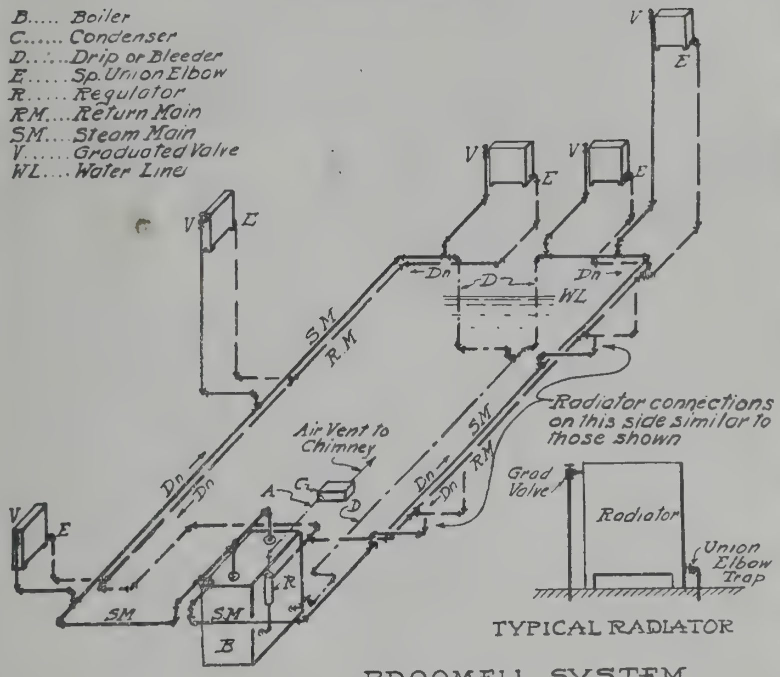
The return lines serve to convey the water of condesation, together with the air, back to the point where the air separation takes place. In systems supplied from a street main and provided with a condensation meter a receiver is used, this being illustrated in Fig. 6. Such receivers have a minimum water depth of 30-in. and the outlet pipe to the meter carried up to a height 8-in. below the top. In Fig. 6, A indicates air vent pipe; B, return lines and C the outlet to the meter. The diameter of these receivers is recommended to be as follows:

Radiation Sq. Ft.	Diameter of Receiver Inches.
600	5
1200	6
2000	8
6000	10
12000	12
20000	16

The air pipe is usually made 1¼-in. and the air lines should be run at least 12 to 15 ft. above the water-line, terminating outside the building wall or carried up through the roof.

VAPOR HEATING.

The Broomell System.



BROOMELL SYSTEM

The general scheme of piping is illustrated in Fig. 1. The pitch of the steam main is downward in the direction of flow and should not be less than ½-in. in 10 ft., with more if possible. Where circumstances make it necessary to pitch the main or its branches back against the steam flow the pitch should not be less than 2-in. in 10 ft., with more if possible. The size of the main is determined by the schedule shown in following:

Radiation. Square Feet	Supply. Inches Diam.	Return. Inches Diam.
100- 300	2½	1
300- 500	3	1¼
500- 900	3½	1½
900-1500	4	1½
1500-2000	4½	2
2000-3000	5	2½
3000-5000	6	2½
5000-9000	7	3
9000-14000	8	5

The drop in pressure is so small when the steam main is sized on this schedule as to sometimes be less than 2 oz. in a 12-story building, and the cross sectional area will be found to be about 0.009 sq. in. per square foot of radiation.

The risers are sized from the schedule shown below:

Radiation Square Feet	Supply Inches Diam.	Return Inches Diam.
100-Less	1	¾
100- 200	1¼	¾
200- 300	1½	¾
300- 500	2	1
500- 800	2½	1
800-1000	3	1¼
1000-1200	3½	1½
1200-	4	1½

(To Be Continued.)

VAPOR HEATING.

The Broomell System.

(Continued from Data Sheet No. 132-D)

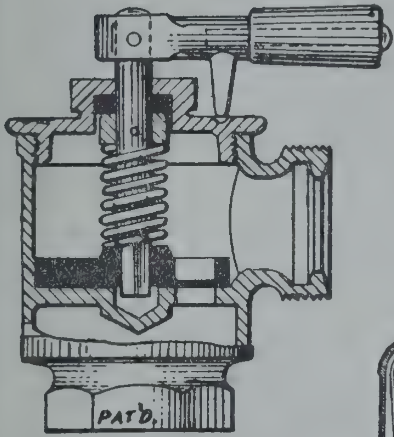


FIG. 2—QUINTUPLE VALVE.

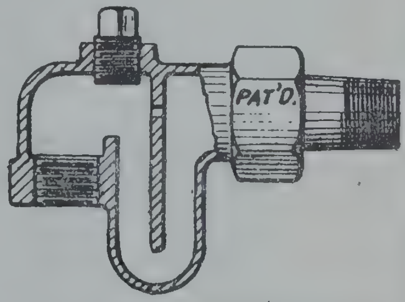


FIG. 3—DIRECT-RADIATOR RETURN CONNECTION.

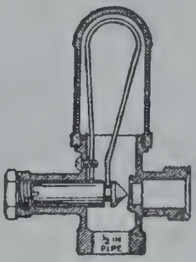


FIG. 4—INDIRECT-RADIATOR RETURN CONNECTION.

The interior construction of the "Quintuple" valve is shown in Fig. 2. Supply valves are made in six sizes for ¾-in. pipe and one for 1-in. pipe (No. 6). The sizes of the valves used on various capacity radiators is given in Table III.

TABLE III

Size of Radiator Square Feet	Valve
Up to 15	No. 0
15 to 35	No. 1
35 to 70	No. 2
70 to 100	No. 3
100 to 140	No. 4
140 to 200	No. 5
200 or more	No. 6

Valves Nos. 0 to 5inc. have ¾-in. tapping; No. 6 has 1-in. tapping.

The radiators have top inlet and bottom outlet at opposite ends and are, of course, of the water type; the surface is figured on the basis of 200 B. T. U. per square foot of radiation and no addition is made for "condensing" as the vapor heats the radiator all the way up to the return end.

On the return connection of all direct radiators a special water-sealed union elbow is used, its construction being illustrated in Fig. 3. The design of this ell permits the ready flow of condensation through the water seal, while the air is relieved gradually through the small by-pass hole in the partition above the seal. On the return connection of indirect radiators, a return trap is used, shown in Fig. 4. The operation of this return trap is intended to prevent any loss of vapor through the return should the heat register or cold-air damper be closed, preventing the circulation of air through the radiator. From the return ells the air and condensation flow back to the main return pipe and thence to the water seal at the top of the receiver.

(To Be Continued.)

VAPOR HEATING

The Broomell System

(Continued from Data Sheet No. 132-E)

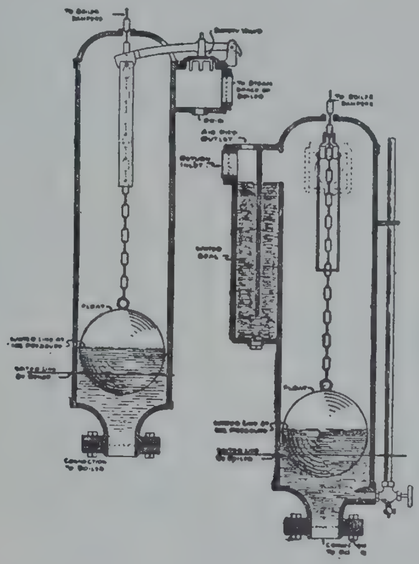


FIG. 5.

At the receiver the water seal causes a separation of the air and condensation, the air passing up into the air line which is connected to the chimney. In this line is placed a small amount of condenser surface for the purpose of reducing to water any vapor which may be contained in the air, thus making the air exhaust into the chimney absolutely dry.

In running the return main the line pitches down continuously to the entrance of a combined regulator-receiver at a grade of not less than ½-in. in 10 ft. The horizontal runs between the union elbow and the riser for radiators on upper floors pitches toward the riser and is made ½in. in size while the risers are not made less than ¾-in. and are connected to the return main through horizontal branches which pitch down toward the main.

After being separated from the air the water of condensation sinks down in the receiver and eventually finds its way into the boiler through the lower pipe connection.

A detail of the receiver is shown in Fig. 5 and it will be noted that the water in the receiver has its surface vented to the air through the opening in the shell just above the relief valve; the return inlet at the same time is water-sealed, as well as the air-pipe outlet.

The distance between the wate-line and that of the extreme high water of the receiver should never be more than 18-in. so that the maximum boiler pressure cannot exceed ¾-lb. Tappings for these receivers are as given in Table IV.

TABLE IV

Radiation Square Feet	Receiver Size	Return Tapping In. Diam.	Air Line In. Diam.
2000 or less	No. 1	2	1¼
2000-4000	No. 2	2½	1½
4000-or up	No. 3	3	2

VAPOR HEATING.

The Moline System.

A typical layout of the Moline system is shown in Fig. 1. It is a two-pipe arrangement, the steam line carrying the steam or vapor from the boilers to the radiators and the return line carrying the air and condensation from the radiators back to the boiler. At that point the water enters the boiler and the air is drawn into the ejector fitting (Fig. 4) which discharges a mixture of air and steam into the condenser. Here the steam is condensed, the water finding its way back to the boiler by way of the condenser drip (through a check valve, along with the condensation from the return line) the air going out of the system through the special air trap and vacuum valve (Fig. 5).

An innovation in this system is the use of a lock-shield globe valve on the return end of each radiator and another is the use of the ejector fitting to produce a pull on the return lines of greater intensity than can be secured by simply opening the return line to the atmosphere or even by connecting the air-vent line to the chimney and employing the chimney draft.

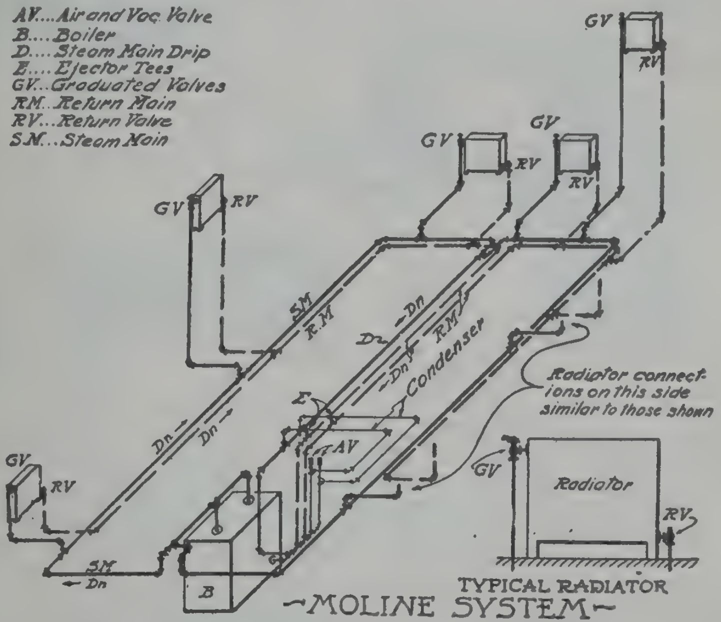


FIG. 1.

In the radiator supply valve (Fig. 2) a slotted sleeve is placed around the disc so that the disc will open these slots or ports gradually as it rises past the openings. The number of slots in the sleeve determines the quantity of steam which will flow for a given rise of the disc and the sleeves are arranged and sized to suit any size of radiator.

The radiator return valves (Fig. 3) are all ½-in. and are of the lock-shield type. They are also provided with an interior sleeve, having small perforations, which allows the water and air to pass without permitting the loss of an undue amount of steam. They are adjustable to suit any condition of service.

The illustration of the ejector (Fig. 4) indicates how the steam or air under pressure in the steam line blows out through the nozzle of the ejector fitting, creating by its velocity, a suction around the jet, this suction drawing out the air from the return lines and discharging the mixture into the condenser. Connecting this ejector near the point where the steam main drops down under the water-line takes the place of an air valve at this point. The steam used to operate this device is condensed in the condenser coil and there gives up its heat. By placing the condenser coil in the basement this serves to heat that part of the building.

(*Continued on Data Sheet No.* 132-H.)

VAPOR HEATING.

The Moline System.

(Continued from Data Sheet No. 132-G.)

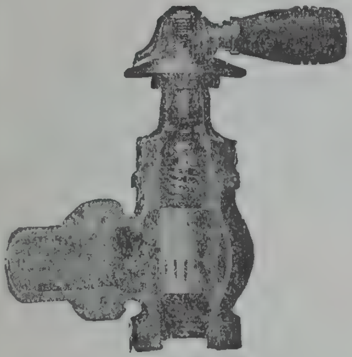


FIG. 2.

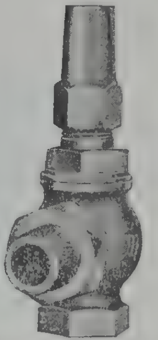


FIG. 3

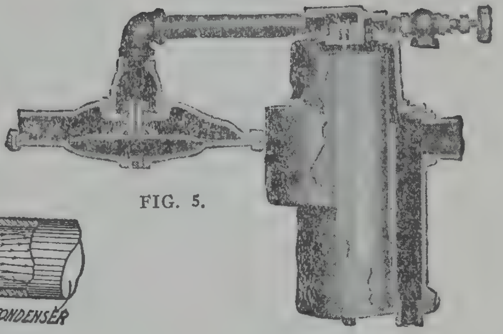


FIG. 5.

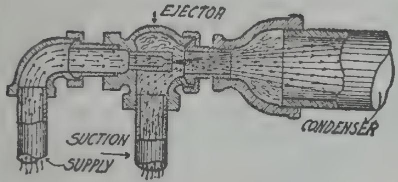


FIG. 4.

The operation of the air trap (Fig. 5) is that of an enormous vent valve and is accomplished by the expansion and contraction of the air contained in a float with an open bottom. No expansion post or volatile liquid is used in this trap. The trap allows the air to discharge into the pipe shown, on which is placed a vacuum valve. The function of this valve is to close off and prevent the return of air into the system whenever the pressure falls below that of the atmosphere.

In sizing the piping for this system the schedule shown in Table I may be used if the length of the mains does not exceed 100 ft. Each elbow should be counted as 10 ft. additional run.

No horizontal supply branch is reduced to less than 1 in. and no horizontal return branch to less than ¾-in., while all supply mains are made 2 in. or over. The sizes of risers are ordinarily made at least one size larger than the radiator valve and, if there are turns in the line, they are made two sizes larger, the increase being made immediately below the radiator valve.

TABLE 1.

Equivalent Direct Radiation Sq. Ft.	Steam Supply In. Diam.	Dry Air and Water Return, In. Diam.	Wet Return, In. Diam.
450	2	1	1¼
750	2½	1¼	1¼
1,350	3	1½	1½
2,000	3½	2	2
2,700	4	2	2
3,600	4½	....	2
4,700	5	....	2
7,500	6	....	2½
11,000	7	....	2½
15,600	8	....	3
21,000	9	....	3
28,000	10	....	4
44,500	12	....	4

VAPOR HEATING.

The Webster System.

The layout of a typical Webster modulation system is illustrated in Fig. 1. Steam is fed to the radiator at the top in the customary manner while the returns pass out of the radiator through a trap, and return to the boiler through a check valve, the air being relieved on the way by means of the Webster modulation vent trap.

The supply to the radiator is controlled by means of the Webster modulation valve which is produced with six different styles of handles although the No. 10 handle (illustrated in Fig. 2) may be considered as the standard, owing to its greater popularity. This valve is constructed as shown in the cross-section, Fig. 2, and controls the flow of vapor into the radiator by lifting a valve cylinder with a diagonal cut past the valve seat so as to increase and diminish the orifice.

On the return end of the radiator a positive trap is used, this being preferably the "Sylphon" trap, a thermostatic trap with the expansion member formed by a sylphon bellows made of seamless tubing with twelve corrugations. A cross-section of this trap is shown in Fig. 3. Owing to its thermostatic operation it will pass cooled condensation or air but closes when hot steam strikes the bellows.

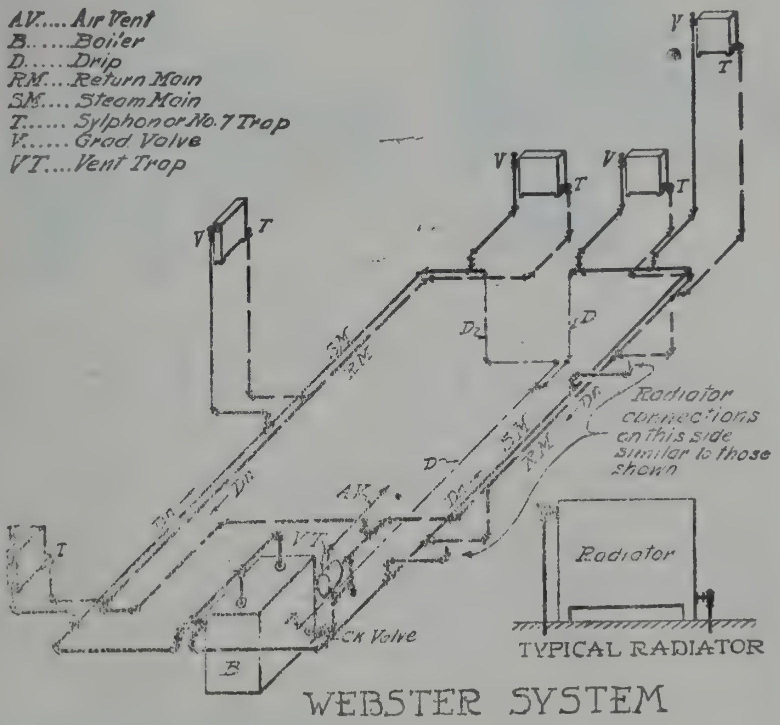


FIG. 1.

Another slightly cheaper type of trap which is sometimes used by the same organization is known as the No. 7 trap. This second type of trap is of the multi-diaphragm type and its operation is similar to that of other disc traps already described.

Water radiators are used and the claim is made that this system of vapor heating can do everything which can be done with hot water and a few things which with hot water are impossible.

The piping system is designed so as to secure the circulation of the vapor with a very small drop—usually not over 2 oz. per 100 ft. of run or its equivalent. The

(*Continued on Data Sheet No.* 132-J)

VAPOR HEATING.

The Webster System.

(Concluded from Data Sheet No. 132-I.)

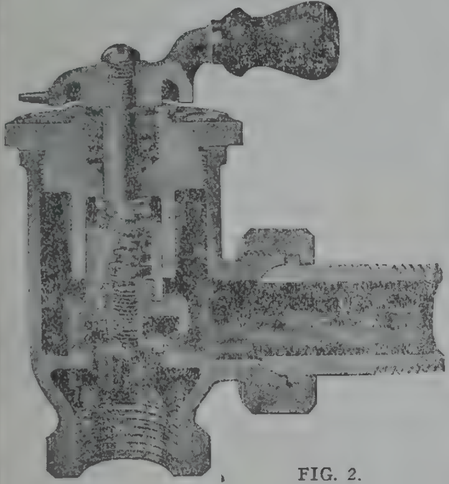


FIG. 2.

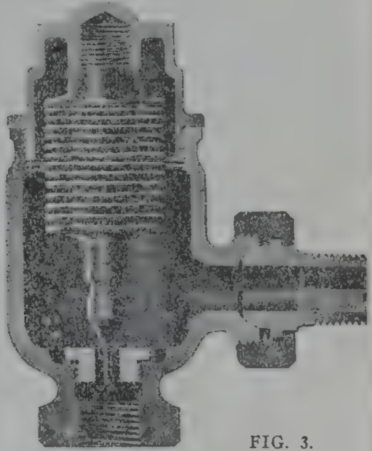


FIG. 3.

ends of the steam mains are dripped into a wet return, which is carried back to the boiler without passing through a check valve. The radiator returns, owing to their carrying air are run back as dry returns to the point where the vent trap is located, and bypass around the trap, entering the boiler through a check valve as shown in Fig. 1. The vent trap, which is illustrated in Fig. 4, operates to relieve the system of air. The air pressure as it accumulates causes the water line in the trap to lower which in turn allows the float to fall, thus opening the valve on the air vent pipe.

The last important item of success in this system is not in any way connected with the piping but is installed directly on the boiler, being the damper regulator. As can be seen in the cross-section view, shown in Fig. 5, this device consists of a lower chamber partially filled with water. From the bottom of this chamber a small pipe is carried up and connected to the lower space below the diaphragm so that any pressure exerted on the surface of the water in the lower chamber will result in driving the water out through the pipe and up into the upper chamber where it exerts an upward pressure on the diaphragm and thus operates the dampers. A steam pipe from the steam main is connected into the regulator just above the water level in the lower chamber and any increase in steam pressure at once begins to drive out the water and thus operates the diaphragm which controls the drafts.

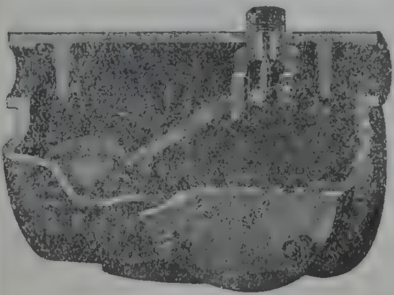


FIG. 4.

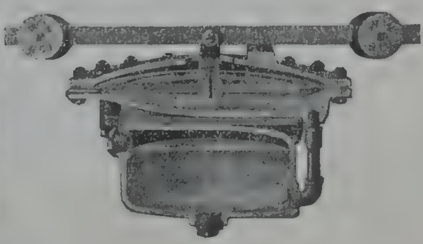


FIG. 5.

VAPOR HEATING.

The Dunham System.

In the Dunham system, as developed by the C. A. Dunham Co., Chicago, Ill., the piping is arranged as shown in Fig. 1. This is a closed return system, with each radiator having a trap which prevents the steam entering the return line.

The steam passes from the boiler B into the steam main SM in the usual manner and up to the radiators, into which it flows through the Dunham packless inlet valve, (Fig. 2). This valve utilizes a series of diaphragms for allowing the free up-and-down movement of the spindle without steam leakage, and at the same time obviating the possibility of leakage without the use of packing or stuffing boxes. This valve is not made in the graduated type (although it is equipped with plate and indicator showing when valve is "On" and "Off") as the Dunham Company does not believe in the possibility of graduating the supply of steam to radiators. The manufacturers state that they believe the amount of steam that will flow through a certain orifice is dependent upon the differential in pressure as between one side of that orifice and the other and that in a heating system this differential is beyond the control of the operator. It is next to impossible to maintain an absolutely constant pressure of steam upon the boiler, and it is quite impossible to regulate accurately the condensing powers of the radiator. Also that while some persons claim that they are able to positively regulate the pressure upon the boiler, no one claims to be able to establish a constancy in the outside weather conditions, the changing of which also changes the condensing capacity of the radiator. The construction of the Dunham valve permits it to be partially opened or closed at will, thus restricting the flow of steam to the radiator the same as for other valves of graduated type.

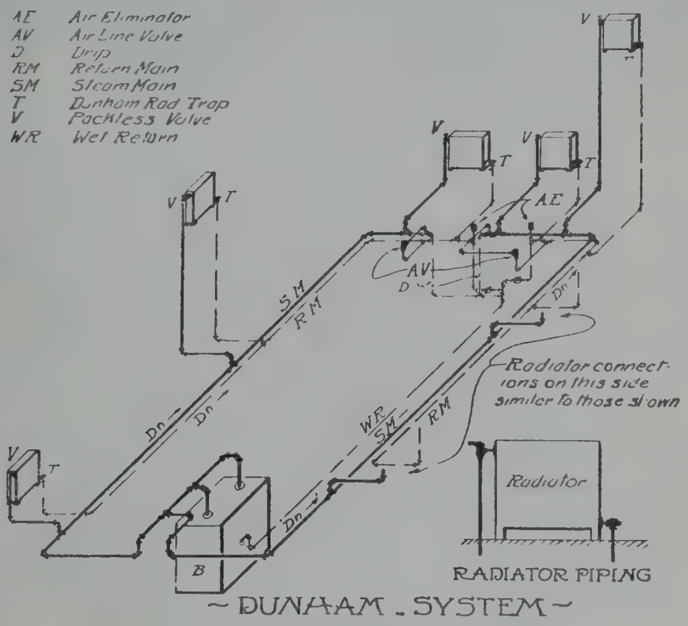


FIG. 1.—TYPICAL LAYOUT OF DUNHAM SYSTEM.

This valve can be used on any two-pipe steam heating system, either vapor, vacuum or pressure. It is made in the angle-pattern, lever-handled type only, and for that reason it is recommended only for radiators with top connection, although it will operate just as satisfactorily when connected to the bottom of radiators.

After passing through the radiator the air and condensation escape through the Dunham radiator trap (Fig. 3).

When the radiator has filled with steam and the steam surrounds the disc in the trap, the volatile fluids within the disc are heated and vaporized, thereby creating a pressure within the disc; this internal pressure expands the disc, the valve seats over

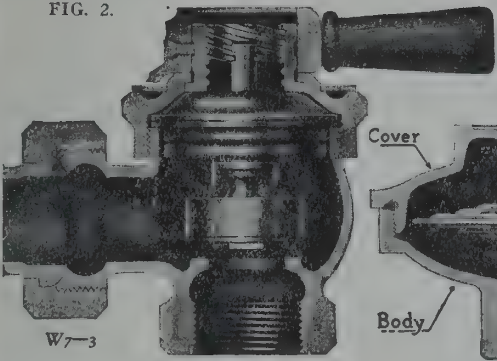
(*Continued on Data Sheet No.* 132-L.)

VAPOR HEATING.

The Dunham System.

Continued from Sheet No. 132-K.

FIG. 2.



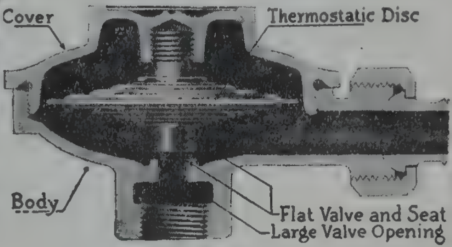
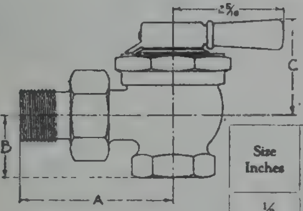


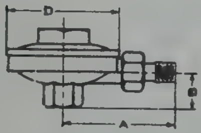
FIG. 3.



(For pressures not exceeding 10 pounds gauge)

Size Inches	Dimensions			Square Feet Radiation
	A	B	C	
½	3	1⅛	1 13/16	Up to 40
¾	3 1/16	1¼	1 15/16	41 to 100
1	3⅛	1½	2⅛	101 to 180
1¼	3 7/16	1⅝	2 7/16	181 to 300

(For pressure not exceeding 10 lbs. gauge.)



Size	Tapping	Capacity Direct Radiation Sq. Ft.	Dimensions				
			A	B	C	D	E
No. 2	½ in.	350	3¾	1¼	2⅝	3 15/16	½

the opening, and waste of steam is prevented. Subsequent water and air forming in the radiator fall to the bottom, surround the disc, condense the gases within it, and the disc contracts, raising the valve from its seat and allowing the air and water to pass out into the return line; steam following behind the air and water, causes disc to again close.

The Dunham radiator trap is for use on all two pipe steam systems, using steam from a minus pressure, as in the case of a vacuum system, up to 10 lbs, pressure above atmosphere; it can be applied on either steam or water type radiators. The use of water type radiators is recommended, however, as circulation through the radiator takes place more quickly and at a lower steam pressure.

The steam main pitches on down to the point when the last radiator connection is taken off. Here an air vent is located to relieve the air, the pipe being run to a Dunham air line valve which permits the air to escape into the return line, while the condensation flowing along the main is relieved by a drip at the end of the main which drops down under the water line and is connected to the wet return to the boiler.

The return main runs parallel with the steam main and pitches down in the same direction. At the end of the run a tee is placed and the condensation passes off through the bottom outlet of the tee and back into the boiler through a check valve. The level of the return main must be kept at least 24-in. above the boiler water line as far as the location of the above mentioned tee.

This is owing to the fact that from the top outlet of the tee a connection is made to a Dunham air eliminator valve which relieves all the air in the system by allowing it to escape into the atmosphere.

VAPOR HEATING.

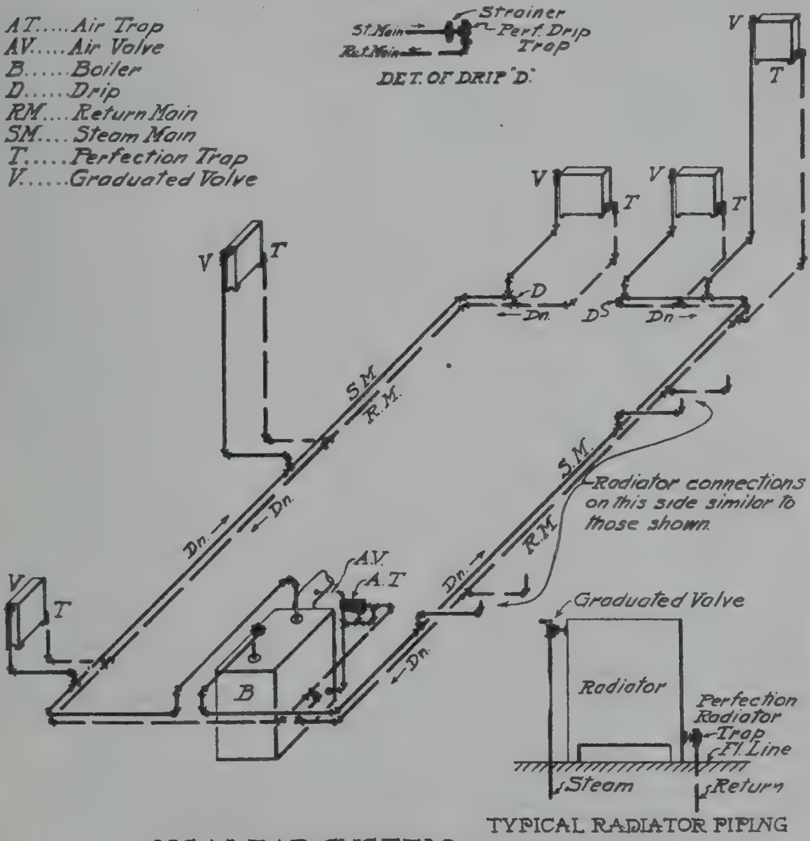
The McAlear System.

McAlear vapor and atmospheric appliances, manufactured by the McAlear Mfg. Co., Chicago, Ill., are separated into two distinct systems which are differentiated by this manufacturer as follows:

"A vapor system is one which generally operates within 2 lbs. of atmosphere and should be provided with some positive means to return condensation to the boiler at any pressure difference between the boiler and the returns."

"An atmospheric system is one which is operated at within a few ounces of atmosphere and depends for its successful performance on very sensitive damper regulation, since any rise in boiler pressure will prevent the return of the condensation."

The distinction, as above enumerated, practically boils down to this, that a vapor system is capable of carrying up to 2 lbs. gauge pressure (due to the automatic return trap being able to return the water to the boiler under this pressure) whereas the atmospheric system has no such return trap and, therefore, must operate at a lower pressure of only a few ounces.



—McALEAR SYSTEM—

FIG. 1.

The requirements consist of special modulation valves on the radiator supplies, special traps on the radiator returns, a special return trap or special air valve at th

(*Continued on Data Sheet No. 132-N.*)

VAPOR HEATING.

The McAlear System.

(Continued from Data Sheet No. 132-M.)

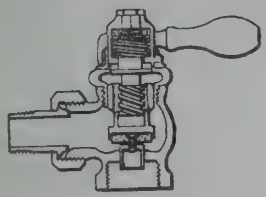


FIG. 2.

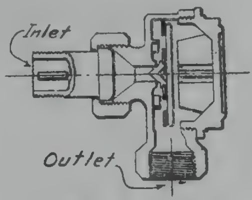


FIG. 3.

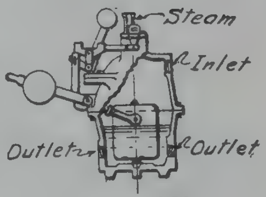


FIG. 4

boiler and (with the atmospheric system) a special super-sensitive damper regulator.

The *vapor* system is illustrated in Fig. 1. The steam and return mains must be liberally sized so as to reduce the pressure drop to a minimum, while the return should be only one or two sizes smaller. The mains must be properly pitched and drained through traps to prevent steam blowing through into the return line. The return must be run without pockets and be pitched in the direction of flow in order to permit freedom of air removal.

The modulation valves are of the packless type (Fig. 2) and are made in sizes and carry the dimensions shown in Table I.

TABLE I.

	Inches.				
Size of valve	½	¾	1	1¼	1½
Face of outlet to center line of outlet	1¼	1 5/16	1½	1¾	2
Face of inlet to center line of outlet	2½	2⅞	3¼	3½	3⅞

These valves are made in angle pattern only and employ varying discs to suit the different sizes of radiators.

On the return end of each radiator is placed a Perfection radiator trap (Fig. 3). By swinging on the union the outlet may be pointed down or 45° forward or back. This obviates the necessity of using right and left-hand valves. These traps, known as No. 28, come in one size only ½-in., and are good for anything up to 300 sq. ft. of direct cast-iron radiation. For blast coils and other large amounts of surface, a larger trap is made. The dimensions of No. 28 are:

Face to center of inlet, 2 1/16 in.; face to center of outlet, 2½ in.; diameter of valve body, 2⅜ in.

After passing through the radiator trap, the air and condensation follow down the return line and back to the boiler. Near the boiler the return line has connected in parallel an "air exhauster and return trap" (Fig. 4). It operates whenever the boiler pressure is sufficient to back up the return into its chamber. The principle of operation is the rising return which lifts the float and opens the steam inlet. This equalizes the pressure on both sides of the water so that the water falls into the boiler by gravity. After discharging, the air relief opens, relieves the steam pressure, the returns again flow into the trap and the process is repeated.

(Concluded on Data Sheet No. 132-O.)

VAPOR HEATING.

The McAlear System.

(Concluded from Data Sheet No. 132-N)

The *atmospheric* system follows throughout the same piping, valves and radiator connections described for the *vapor* system *except at the point where the returns enter the boiler.* Here no automatic return trap is provided but instead a Kieley air trap is substituted, this trap being constructed as shown in cross section in Fig. 5 and with the piping arranged as shown in Fig. 6. These traps are built in eight sizes for various heating system capacities, as shown in Table II.

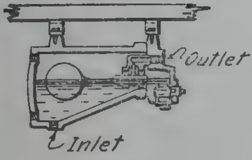


FIG. 5.

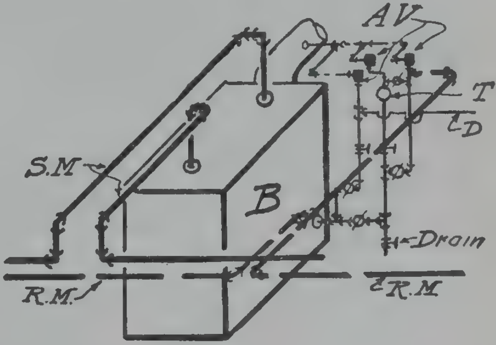


FIG. 6.

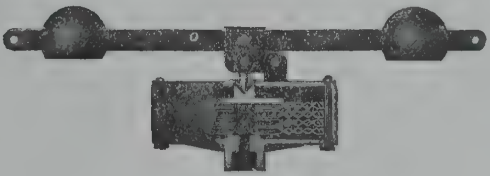


FIG. 7.

TABLE II.

No. of Trap.	Sq. Ft. Radiation.
0	0 to 900
1	901 to 1300
2	1301 to 2000
3	2001 to 3300
4	3,301 to 5000
5	5001 to 8300
6	8301 to 11500
7	11501 to 16500

As can be seen, this trap simply and solely relieves the air from the system and does nothing to help return the condensation against the boiler pressure. Thus, a very small increase in the boiler pressure is sufficient to flood the return and air bind the system if the return main is anywhere near the same level as the boiler water line. For this reason a vapor regulator is used to control the heating boiler, this being a very sensitive device which gives control of the boiler pressure by ounces and will operate at any pressure from 3 lbs. gauge down to 5 in. of vacuum.

VAPOR HEATING.

The Sterling System.

In the Sterling system, manufactured by the Sterling Engineering Co., Milwaukee, Wis., the boilers, radiators, pipe and fittings are the same as those used on other types of systems. The return pipe from the radiators, however, is connected into a general return main on which an air eliminator is installed; it is open to the atmosphere until all the radiators are full of vapor. This, of course, permits the vapor to flow into the pipes and radiators without resistance, immediately filling the entire system with vapor to the point where the thermostatic trap is installed on the bottom of the radiator. When the vapor reaches this point it comes in contact with the diaphragm in the miniature trap installed on each radiator. The operation then follows the usual course, the vapor causing the volatile liquid to expand, preventing the escape of vapor from the radiator.

The air and water are carried in the return pipe to the basement, the air from the system being discharged to the atmosphere through the automatic air eliminator, and the water or condensation being returned to the boiler. Means are taken through the use of an automatic vapor damper regulator to keep the vapor in the boiler at a uniform pressure and the graduated supply valve on each radiator (Fig. 1) places the room temperature under the control of the occupant. These supply valves are of the packless quick-opening type. They have the desirable feature that the tension between the packless disc and the stem can be regulated by loosening or tightening the screw in the top of the handle. The valve can be easily taken apart.

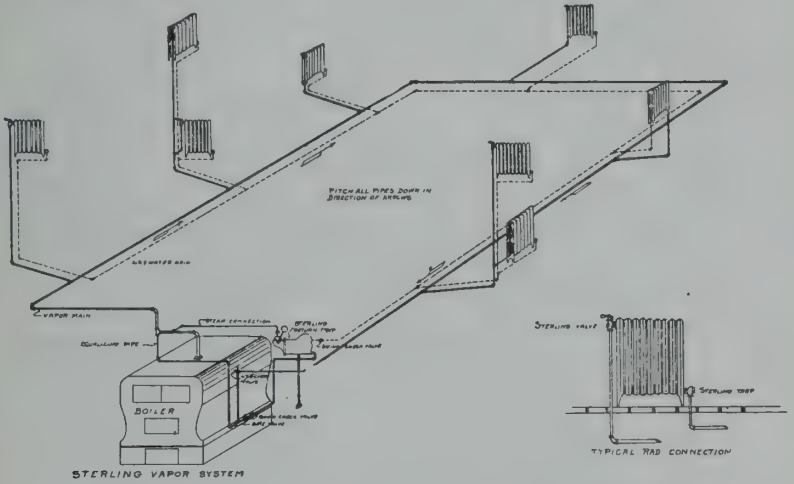


FIG. 1—TYPICAL LAYOUT OF THE STERLING SYSTEM.

In the construction of the Sterling diaphragm radiator trap it may be noted that the diaphragm cannot collapse from pressure and that it has a continuous, rather than an intermittent, discharge. It also has a vertical self-cleaning seat, while the diaphragm is concave, assuring flexibility.

A unique feature of the Sterling thermostatic trap is the adjustment device by which the position of the diaphragm in relation to the seat can be regulated without removing the trap from the radiator or disconnecting it from the return line. By means of this adjustment, the diaphragm can be set in the proper position with the steam turned on and thus an accurate adjustment made. After once set in place, the lock screw is turned down against the end of the diaphragm stem, preventing the diaphragm from getting out of adjustment. The adjustment is covered by a washer and name plate which are held in place by a threaded ring in the top of the cover, thus hiding the adjustment from the eye and preventing same from being tampered with.

Regarding the air eliminator used, this should be placed at least 30 in. above the water-line of the boiler. It is a self-contained unit and has a check to prevent outside air from being drawn into the system.

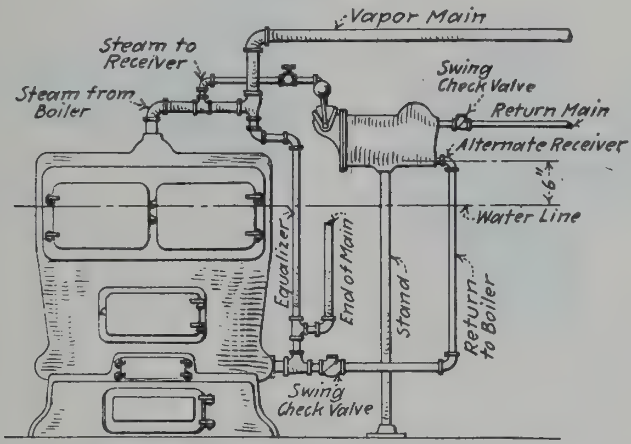
(*Continued on Data Sheet No.* 132-*Q*.)

VAPOR HEATING.

The Sterling System.

(Continued from Data Sheet No. 132-P.)

The Sterling alternate receiver, used on large vapor installations or where the distance between the water level in the boiler and the level of the return line at the boiler is less than 30 in., is an ingenious device, designed to return the water to the boiler against pressure.



PROPER METHOD OF CONNECTING STERLING ALTERNATOR AND AIR SEPARATOR

The valve in the Sterling alternator and air separator never leaves its seat. It is of the slide-valve type and as the trap or receiver fills and discharges, thus raising and lowering the float, the slide valve moves forward and backward over the steam and exhaust ports, first allowing the air from the system to escape to the atmosphere, as the receiver fills, and then admitting steam from the boiler, when the receiver is full. This places the receiver under boiler pressure and causes the condensation to return to the boiler by gravity. The level of the outlet of the receiver can be within 6 in. of the water-level of the boiler.

The Sterling alternate receiver and air separator is for use especially on large installations or where it is not practical to use the air eliminator owing to lack of space to install the air eliminator 30 in. above the water-line. The alternate receiver can be placed as low as 6 in. above the boiler water-line, as there is no relation between the pressure carried on the boiler and on the return main when this receiver is used. It is capable of draining the system thoroughly, eliminating the air without loss of vapor and discharging the condensation to the boiler, regardless of the pressure carried, up to 25 lbs. It also prevents air from being drawn into the system and makes an excellent return trap.

(Concluded on Data Sheet No. 132-R.)

VAPOR HEATING

The Sterling System

(Concluded from Data Sheet No. 132-P.)

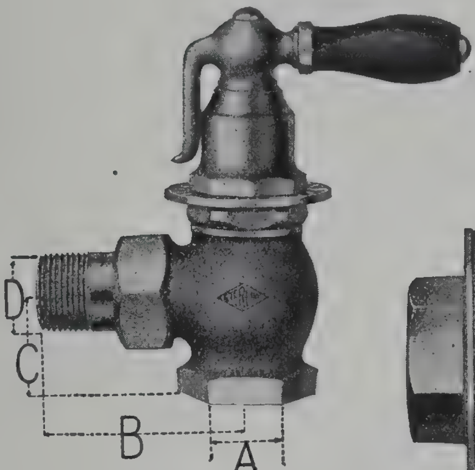


FIG. 2—STERLING RADIATOR VALVE.

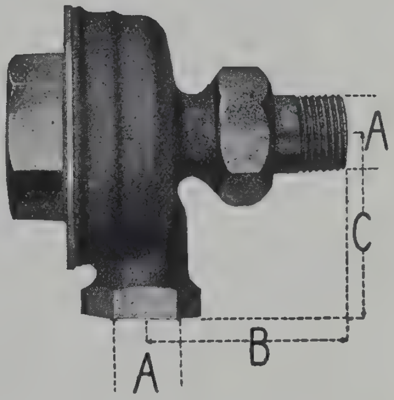


FIG. 3—STERLING RADIATOR TRAP.

ROUGHING-IN DIMENSIONS OF STERLING VALVES AND TRAPS.

No. of Valve	A	B	C	D	Capacity
A	¾	2⅜	1¼	½	Up to 70 ft.
B	1	2¾	1⅜	¾	70 to 150 ft.
C	1¼	3¼	1⅝	1	150 to 225 ft.

No. of Trap.	A	B	C	D	Capacity
1	½	2⅜	1¾		Up to 75 ft.
2	½	2¼	1⅞		75 to 200 ft.
3	¾	2⅝	2½		200 to 500 ft.

NOTE—The above measurements are given in inches, capacities in square feet of radiation. For radiators 20 in. and lower in height and long radiators on coils use valve one size larger.

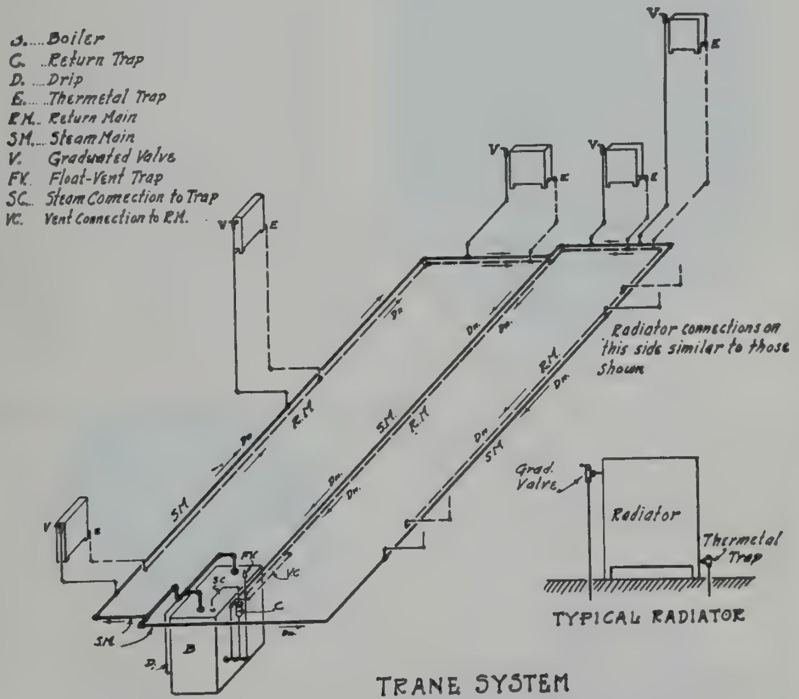
VAPOR HEATING.

The Trane System.

In the Trane System of vapor heating, developed by the Trane Co., La Crosse, Wis., use is made, in the larger installations, of the Trane Thermetal trap on the return end of the radiator. This trap is of such unique construction and has created such a stir in engineering circles as to give it special prominence among the radiator traps now on the market.

A typical layout of the Trane system is shown in Fig. 1. The specialties used consist of a vapor regulator for controlling the draft, a direct-return trap, a graduated vapor valve for the radiator inlets and the Thermetal valve already mentioned for the radiator return connection.

FIG. 1.



For smaller installations the company has a special return fitting for use in place of the Thermetal trap, and a receiver and air exhaust valve in place of the direct-return trap, for separating the air and returning the water of condensation to the boiler.

In installations where the Thermetal trap is used, the system is made safe, regardless of the pressure, through the direct-return trap (Fig 2). If, for any reason, due to faulty handling or mismanagement, the fire is allowed to burn too vigorously and a pressure is created on the system so that the water will not return by gravity, the water fills up the body of the direct-return trap, lifting the float and finally, when the float reaches the top, the steam valve in the top of the direct-return trap opens, forcing the water back into the boiler. The vent valve on top of the direct-return trap is also closed so that steam will not pass into the returns.

When the water is forced into the boiler, the float lowers and again operates the steam and vent valve, closing the steam valve and opening the vent valve, so as to equalize the pressure in the direct-return trap body with that of the return piping, thus allowing the water to again flow into the direct-return trap body by gravity. This operation is continuous so long as there is pressure on the boiler in excess of that required.

(*Continued on Data Sheet No. 132-T.*)

VAPOR HEATING.

The Trane System.

(*Continued from Data Sheet No. 132-S.*)

The manufacturers advocate the use of a direct-return trap on all gravity plants where the radiators are equipped with traps, because on such plants there is always a difference in pressure between the supply and the return, due to the operation of the radiator trap.

The fact that the Thermetal trap (Fig. 3) is a comparatively recent development lends special interest to its construction and operation. It is a thermostatic trap, but instead of being actuated by a mass of liquid, this function is performed by a mass of metal. Through the circular construction of the operating mechanism, an unusual expansion per degree difference in temperature has been obtained, while, at the same time, a straight-line motion makes it adaptable to the ordinary type of thermostatic trap. It is also to be noted that the trap is affected by temperature only and not by pressure. This makes it an easy matter to design these traps for various differences in steam pressures.

The vapor regulator, shown in Fig. 4, is connected into the steam dome or into the supply pipe on top of the boiler, and chains run from the end of the lever arm to the draft door and to the check draft in the smoke pipe. The pressure in the boiler operates on the body of water in the bottom of the regulator which, in turn, forces up the large diaphragm connected to the lever arm, closing the draft as the pressure increases, and opening it again as the boiler pressure goes down. An adjustable weight on the lever arm permits any desired boiler pressure to be maintained.

A feature of the radiator inlet valve (Fig. 5) is that opening the valve lifts the disc from the seat and at the same time raises the shell or sleeve gradually past a port in the side of the valve so that the supply of vapor to the radiator is proportioned at all times to the position of the valve handle. The sleeve rises and revolves at the same time, giving a revolving motion, and serving to keep the sleeve clean, thus preventing scratching or scoring of the valve body.

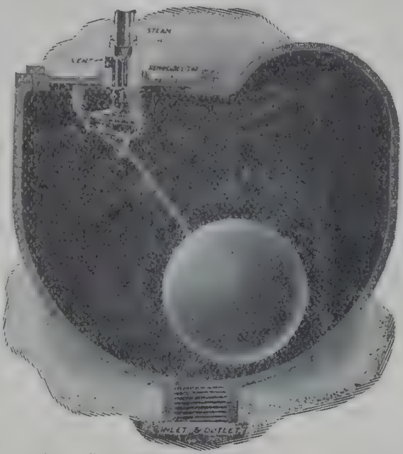


FIG.2—CONSTRUCTION OF TRANE DIRECT RETURN TRAP.

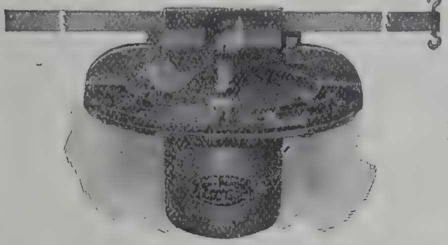


FIG. 4—VAPOR REGULATOR USED WITH TRANE SYSTEM.

Water types of radiators are used with this system, tapped top and bottom, opposite ends for first floor and the same end for upper floors. The return should have eccentric bushings.

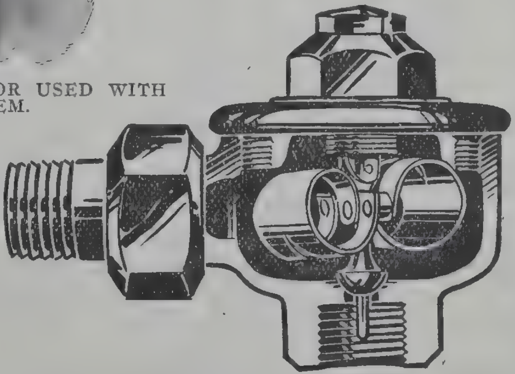


FIG. 3—CONSTRUCTION OF TRANE THERMETAL TRAP.

(*Concluded on Data Sheet No. 132-U*)

VAPOR HEATING.

The Trane System.

(Concluded from Data Sheet No. 132-T.)

For smaller installations of the Trane system, the company recommends the use of a receiver in place of the direct-return trap and a special return fitting at the return end of the radiator in place of the Thermetal trap.

The receiver (Fig 6) is primarily a safety device, its function being to receive the air and condensation coming back from the radiators, to vent the air from the system without permitting the escape of steam, and to return the condensation to the boiler under all operating conditions. While in the larger installations the direct-return trap is used to make the system safe, in smaller installation this is accomplished by the receiver. Under ordinary conditions, the air will be vented and the condensation will return to the boiler by gravity. If the boiler pressure should happen to increase, the condensation collects in the receiver until there is a sufficient amount to raise the float. When this occurs, it closes the air vent to the atmosphere, sealing the system, and the difference in pressure between the boiler and receiver then becomes so small that the water will flow back to the boiler. This operation is automatic and will continue as long as the pressure in the system is higher than that ordinarily required. There is at the top of the receiver an exhaust valve, allowing the air to escape from the system and preventing the escape of steam.

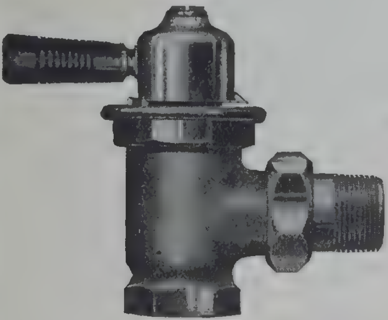


FIG. 5—TRANE RADIATOR INLET VALVE.

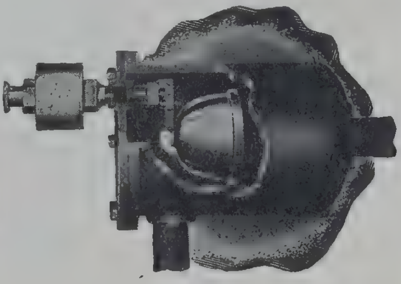
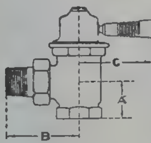
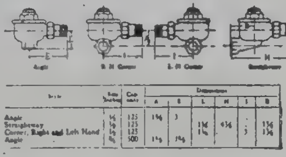


FIG. 6—RECEIVER OF TRANE SYSTEM.



Inches Size	A	B	C
½	1⅜	2½	[illegible]
¾	1½	2½	[illegible]
1	1½	2½	[illegible]
1¼	1⅝	2½	[illegible]

ROUGHING-IN DIMENSIONS OF TRANE RADIATOR VALVES.



ROUGHING-IN DIMENSIONS OF TRANE THERMETAL TRAPS.

The special return fitting for radiators used in smaller installations has two separate openings for the quick escape of air and water from the radiator. When these return fittings are used, the radiators should be bushed for top and bottom connections as follows:

20 sq. ft. and under	¾-in. x ½-in.
21 to 64 sq. ft	¾-in. x ¾-in.
64 sq. ft. ond over	1 in. x ¾-in.

When Thermetal traps are used the bushings should be:

63 sq. ft. and under	¾-in. x ½-in.
64 to 175 sq. ft	1 in. x ½-in.
176 sq. ft. and over	1 in x ¾-in.

VAPOR HEATING.

The Mouat System.

The Mouat vapor heating system will be found distinctive in its simplicity. It is a Vapor System in a true sense, the range of operating pressure being entirely above atmosphere, running from a fraction of an ounce to a maximum of not over three ounces at the boiler.

There is an absence of any mechanical or thermostatic devices designed either to produce a vacuum or to serve as radiator or boiler return traps.

The pressure is controlled by the Mouat vapor and damper regulator. This is a sensitive device designed to automatically operate the boiler drafts, producing the low, constant pressure so necessary for successful graduated heat control.

The operation of the regulator is as follows: The stationary tank "A" (Fig 1) is connected to the boiler steam space by pipe "B", and is automatically kept full of water to the overflow level "E" by the condensing surface of tank "A" itself. The boiler pressure is transmitted to the top of the water in tank "A," forcing the water through the flexible connection "K" and the hollow arm "C" into the tilting tank "F." The weight of the water causes tank "F" to drop, closing the ash pit damper "G" and opening the check draft damper "H." A slight decrease in the boiler pressure causes a reverse operation to take place. "J" is an adjustable weight permitting the regulator to operate at varying pressures. The regulator is entirely separate from the boiler water-line and is not affected by high or low water in the boiler or by fluctuation due to an unsteady water-line.

The Mouat packless graduating supply valve (Fig. 2) is of the lift seat, compression type; a sleeve attached to the bottom of the seat providing the graduating feature. A sliding stop and locking collar provide a means for adjusting the valve lift, thus enabling individual valve adjustment at each radiator.

The Mouat radiator return fitting (Fig. 3) consists of a vented water seal constructed so as to drain completely when the radiator is turned off, thus preventing freezing. The return fitting presents a retarding influence to the flow of vapor at the radiator outlet, causing the radiator to fill completely with vapor.

The entire system is vented through the Mouat main vent valve (Fig. 4). This valve provides for the removal of all air from the radiators and mains, but prevents the loss of vapor. This is accomplished by a water-seal that forms in the vent valve only when vapor is present, effectually preventing its escape. The vent has no thermostatic or mechanically operated parts.

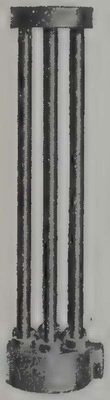


FIG. 4.

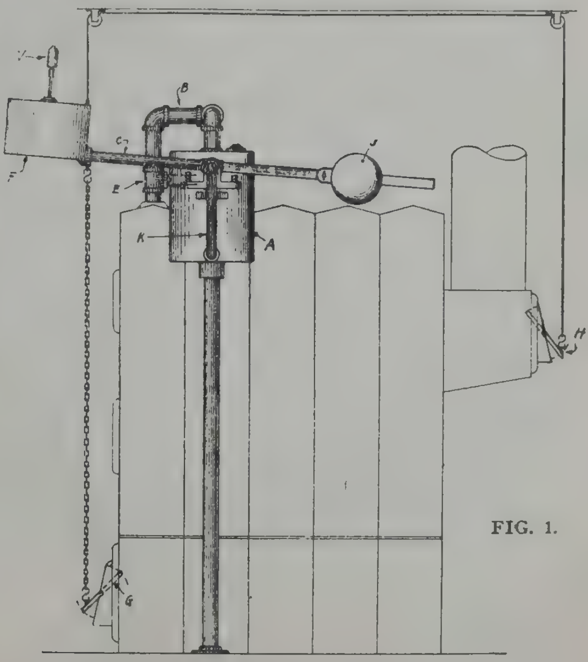


FIG. 1.

(*Concluded on Data Sheet No. 132-W*)

VAPOR HEATING

The Mouat System

(Concluded from Data Sheet No. 132-V)

The general system of piping is shown in (Fig. 5) and is self explanatory. The piping is arranged to produce an even distribution by placing the last radiator to get heat nearest the vent: this will be found to prevent sluggish circulation in the radiators at a distance from the boiler.

With a maximum pressure of 3 oz., at the boiler it is possible to heat buildings of almost any size, the range of satisfactory installations running from a few radiators to hundreds of units. The low, constant pressure carried results in comfort and economy due to successful graduated heat control at the radiators and sensitive regulation of the boiler drafts.

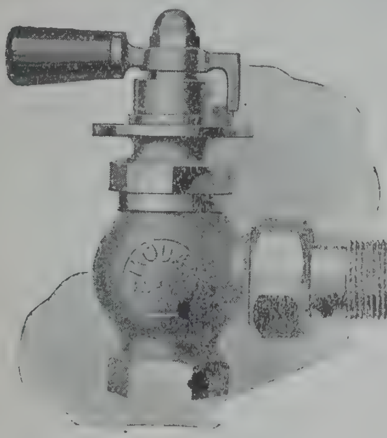


FIG. 2.

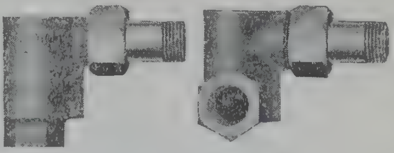


FIG. 3.

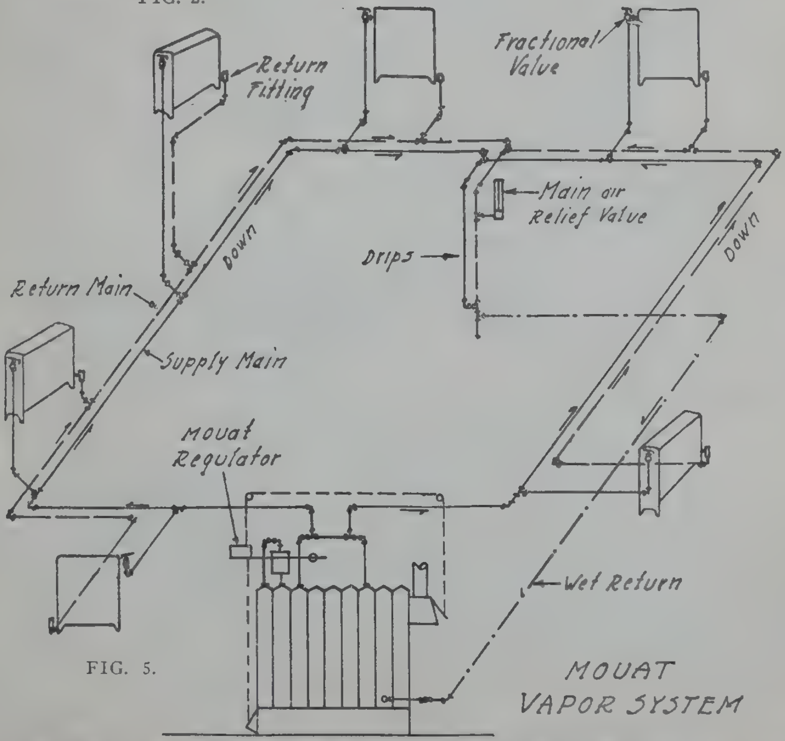


FIG. 5.

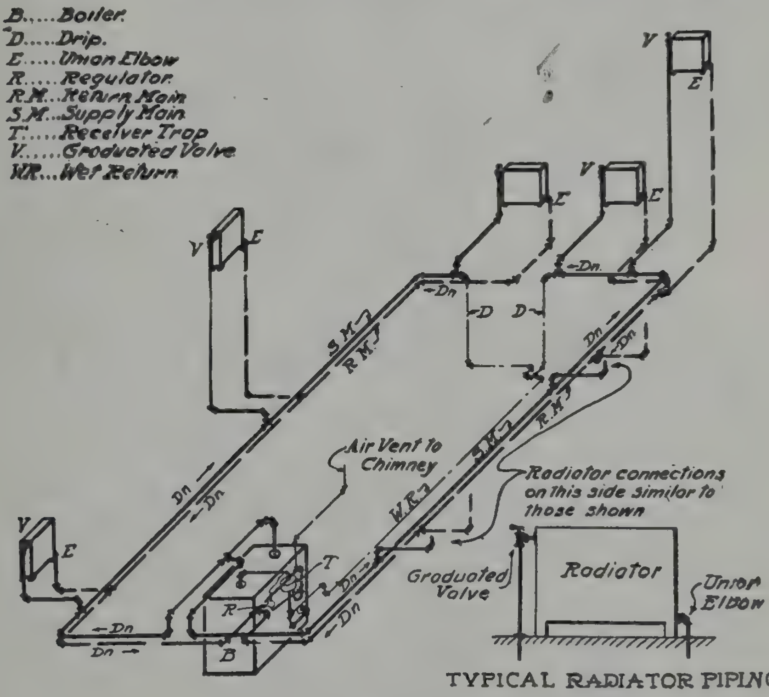
VAPOR HEATING.

The Hutchison System.

A distinctive feature of the Hutchison system, developed by the Hutchison Vapor Heating Corporation, Washington, D. C., is the fact that there is no trap at the individual radiators, the returns being trapped at the boiler by means of the Hutchison trap-receiver and damper regulator combination, shown in Fig. 3.

In Fig. 1 is shown a typical connections diagram for this system. Steam or vapor generated at the boiler flows out through the supply mains and risers and is admitted to the radiators through the Hutchison packless graduating valve (Fig. 2) of which there is one at the inlet end of each radiator. Condensation leaves the radiators through the Hutchison union elbow (Fig. 4) and is fed through the return lines to the trap-receiver at the boiler.

The Hutchison damper regulator is operated by the weight of water which is forced into its reservoir from the trap-receiver upon a rise of boiler pressure and which passes from this reservoir into the trap-receiver upon a fall of boiler pressure. This regulator is adjustable from 2 to 6 oz. pressure by simply changing the setting of the reservoir on its indicator plate and figures opposite each setting on this plate show the pressure of the setting.



-HUTCHISON SYSTEM-

Hutchison special safety valves of the side lever, pop type are supplied in four sizes from 1 in. to 2 in. for boilers of 700 to 3500 sq. ft. radiation; for larger sizes it is recommended that 2 in. safety valves be used, arranged in tandem.

In installing this system the mains should be graded not less than 1 in. in 20 ft. when steam and condensation flow in the same direction, and not less than 3 in. in 20 ft. when steam and condensation flow in opposite directions. An addition of 20% to computations of required steam radiation is suggested, to insure complete condensation of the vapor in the radiator and keep steam out of the return lines. Radiators should be of the water type, tapped for top supply and bottom return, the return tapping being eccentric and either at the same or opposite end of the radiator from the steam connection. Return lines are vented to the atmosphere, and the vent line must be carried up at least 10 ft. above the level of the return line.

(*Concluded on Sheet No.* 132-Y)

VAPOR HEATING

The Hutchison System

(Concluded from Data Sheet No. 132-X)

The Hutchison graduating valve is of the packless type which opens and closes a port by the movement of a tapering slot attached to the valve spindle across the port opening as illustrated in Fig. 2. An extension valve stem is supplied for use in connection with enclosed or concealed radiators.

Pipe size for supply mains depends on the amount of radiation to be heated, the distance from the boiler to the furthest radiator, and the number of elbows contained in such line. The following table is calculated on the basis of an assumed pressure drop of 2 oz. between the boiler and the last radiator. In making measurements an allowance of 10 ft. for each right-angle elbow is suggested.

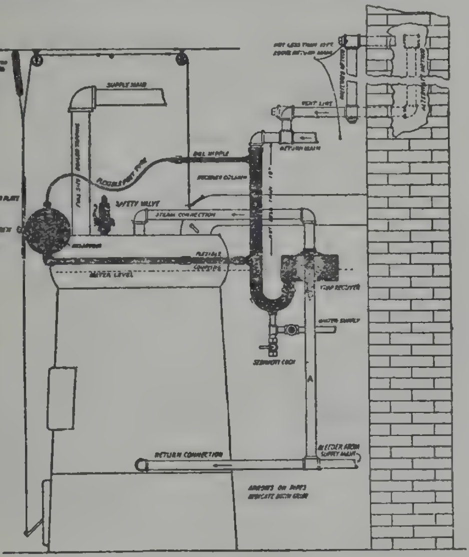


Fig. 3

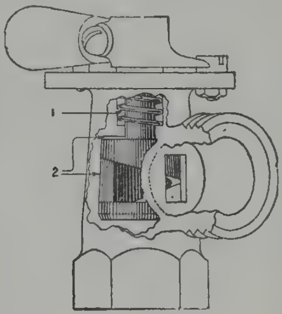


Fig. 2

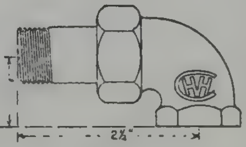
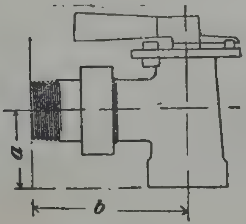


Fig. 4

Nominal Size of Pipe In. Diam.	100 ft. or less	100-150 ft.	150-200 ft.	200-300 ft.
	Length of Run of Main in Lineal Ft. — Radiation in Square Feet.			
1¼	160	145	122	100
1½	265	210	190	150
2	520	450	380	310
2½	860	700	600	490
3	1500	1250	1070	900
3½	2200	1800	1550	1250
4	3300	2600	2200	1800
4½	4500	3700	3200	2600
5	6200	5000	4400	3600
6	....	8400	7200	5800



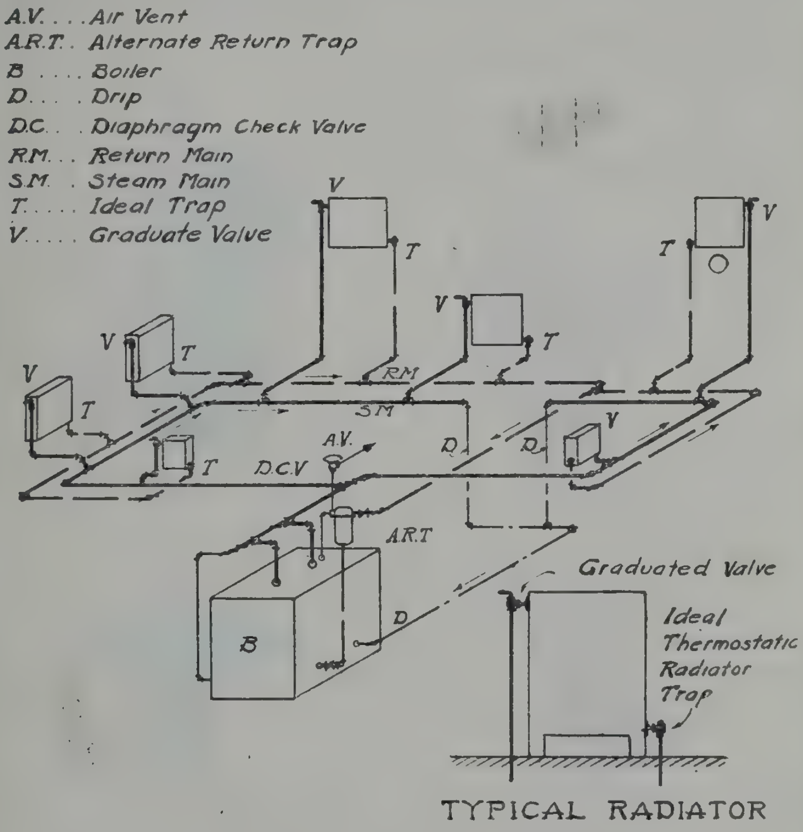
Roughing in Measurements for Radiator Valves

Sizes	a	b
1 inch	1⅞ inches	3¼ inches
¾ "	1⅜ "	3 "
½ "	1¼ "	3 "

VAPOR HEATING.

The Ideal System.

A typical piping diagram of the Ideal System is shown in Fig. 1. Its outstanding feature is the use of the Ideal alternate return trap, shown in Fig. 2, which serves to drain the system of condensation, discharging the same directly into the boiler at any pressure up to 20 lbs. per square inch. This trap is designed to prevent the burning and cracking of boilers due to faulty circulation. It also serves to overcome spitting of water from air eliminators, receivers, or venting valves. The Ideal alternate return trap can be installed as low as 8 in. above the water line in case the boiler room ceiling is low, but a greater height is recommended if possible.



IDEAL SYSTEM

When the system is operating under a few ounces of pressure, the alternate return trap acts simply as an open receiver and air vent. But, if for any reason the boiler pressure rises, the accumulating condensation in the trap lifts a float which automatically closes the air valve and opens the steam valve, admitting boiler pressure to the top of the trap and forcing the water in the trap down into the boiler. After this discharge (or rather along with it) the float drops, closing the steam valve and opening the air valve. A few repetitions of this process will serve to reduce the boiler pressure to a few ounces, allowing the condensation to return again by gravity.

(*Concluded on Data Sheet No.* 132-AA)

VAPOR HEATING.

The Ideal System.

(*Concluded from Data Sheet No.* 132-Z)

Air leaving the alternate return trap, passes through the Ideal diaphragm check valve, shown in Fig. 4, which offers no resistance to its outward flow but prevents any return of air to the system.

What the Ideal alternate return trap is to the system as a whole, the Ideal thermostatic radiator trap is to the individual radiator. This trap as shown in section in Fig. 3, is seen to be of the vertical type which is self-cleaning in operation. Attached to the return end of the radiator this trap serves to drain it of condensation and to maintain within it under proper operating conditions, a satisfactory vacuum.

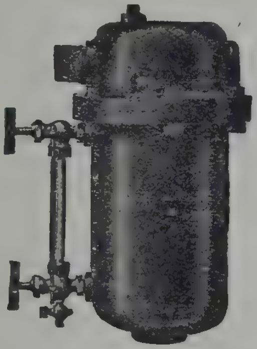


FIG. 2—IDEAL ALTERNATE RETURN TRAP.

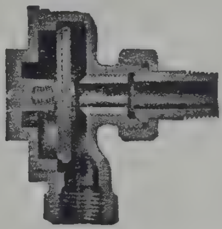


FIG. 3—IDEAL THERMOSTATIC RADIATOR TRAP

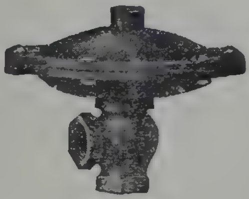


FIG. 4—IDEAL DIAPHRAGM CHECK

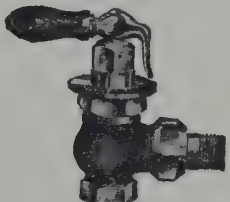


FIG. 5—IDEAL RADIATOR VALVE.

The Ideal radiator valve shown in Fig. 5, is placed at the supply end of the individual radiator and by reason of its graduated dial offers a means for regulating the rate of heat supply. This valve is packless and quick-acting and is so designed that its disc is readily renewable.

Water type radiation is recommended for use in connection with the Ideal System by its manufacturer, the Ideal Heating Equipment Company, Cleveland, O.

VAPOR HEATING

The Imico System

A minimum of special appliances marks the Imico System of vapor vacuum heating, typical piping diagram of which is shown in Fig. 1. There is no air valve at the radiators in this system and no trap on the return end of the individual radiator. Vacuum is maintained in this system by the Dewey tri-duty air and vacuum trap, which is a combination of the Dewey quick vent air valve and the Dewey vacuum valve.

The principle on which the Dewey tri-duty air and vacuum trap eliminates air is very simple. There is a connection from the supply pipe, or pressure side of the boiler, to the diaphragm and under normal conditions this diaphragm is closed. When the fire is started and the air in the boiler is expanded, the diaphragm is inflated and opens the vacuum valve, making a direct opening through the trap to the atmosphere. This valve remains open as long as there is a fraction of an ounce pressure on the boiler, unless the vapor having passed through the entire system is forced into the float chamber, which instantly closes against vapor. If water should be forced up the return pipe, the float rises in the chamber and closes it, keeping it cloed until water recedes, when it opens again and commences venting air. With this trap installed there is no chance for back-pressure in the radiators, since it will close against either steam or water and will prevent the return of air to the system.

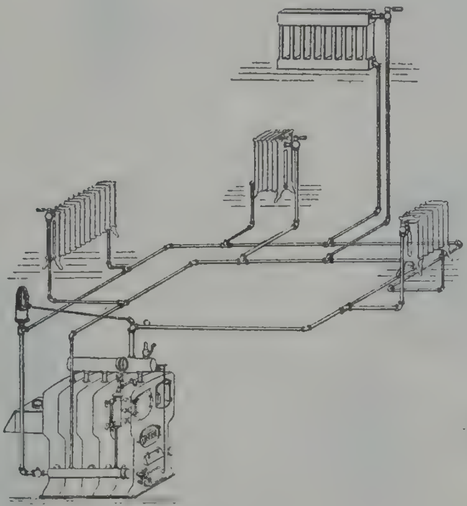


FIG. 1

Radiators for the Imico System of vapor vacuum heating may be the same size as for steam, but an increase of 10% over the radiation as computed for the ordinary steam job, is recommended by the manufacturers, the Illinois Malleable Iron Company, Chicago, Ill., to promote economy in coal consumption. Either steam or water radiation may be used, tapped at the top, and the supply valves at the radiators should be of the graduated type.

The boiler should be provided with a regular safety valve and controlled by a well balanced damper regulator.

(*Concluded on Data Sheet No.* 132-CC)

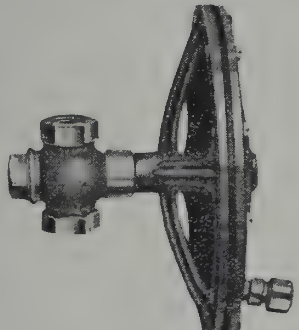
VAPOR HEATING.

The Imico System.

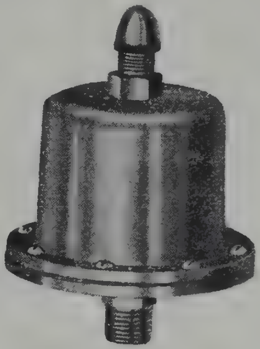
(*Concluded from Data Sheet No.* 132-BB)

Supply Main Sizes

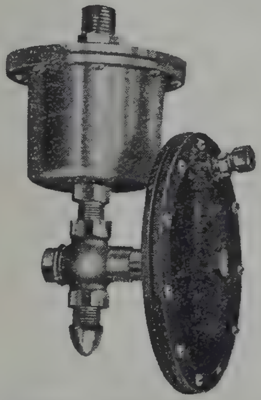
1½-inch	will	supply	200	feet	to	400	feet	Radiation
2	“	“	400	“	“	700	“	“
2½	“	“	700	“	“	1100	“	“
3	“	“	1100	“	“	1500	“	“
3½	“	“	1500	“	“	2000	“	“
4	“	“	2100	“	“	3000	“	“
5	“	“	3000	“	“	5000	“	“



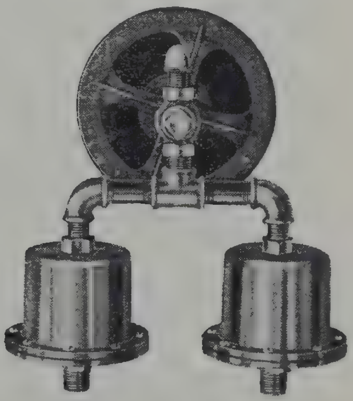
DEWEY VACUUM VALVE



DEWEY QUICK VENT AIR VALVE



DEWEY TRI-DUTY AIR AND VACUUM TRAP.



DEWEY DUPLEX TRI-DUTY AIR AND VACUUM TRAP

Return Pipe Sizes

1	-inch	at	boiler	will	return	200	feet	to	700	feet Radiation
1¼	“	“	“	“	“	700	“	“	1110	“ “
1½	“	“	“	“	“	1100	“	“	2100	“ “
2	“	“	“	“	“	2100	“	“	5000	“ “

Tapping Size for Radiation

Size of pipe supply:

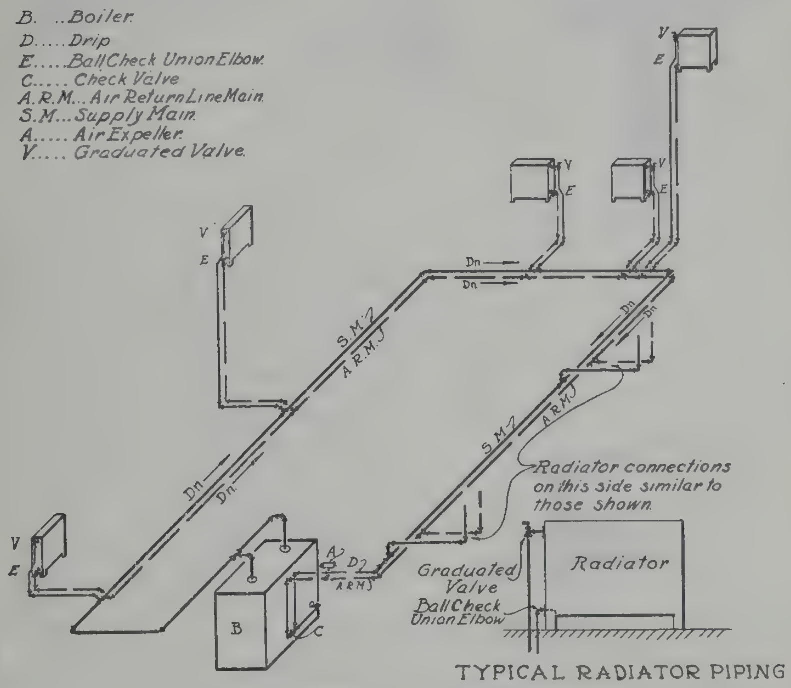
Radiation 90 square feet or less	¾-inch pipe and	¾-inch graduated valve.
“ 90 feet to 150 feet	1 “ “ “	¾ “ “ “
“ 150 “ “ 300 square feet	1¼ “ “ “	1 “ “ “

VAPOR HEATING.

The Richardson System.

A characteristic feature of the Richardson System is the use of the Richardson water-seal ball-check union at the return end of each radiator. This device, shown in Fig. 2, takes the place of a vacuum valve at the radiator and serves also as a return elbow.

A typical piping diagram of the Richardson system is shown in Fig. 1. This illustrates a one-circuit arrangement such as the manufacturers suggest for medium sized installations. It should be noted that a separate ari return-line circuit is provided for the supply circuit and this holds true for such cases as require three or four supply circuits. The manufacturers claim that an air expeller and vacuum valve should be provided for each return line circuit.



~RICHARDSON SYSTEM~

The Richardson air expeller and vacuum valve, shown in Fig. 3, is located on the air return-line near the boiler and serves to vent the air from the system, closing when vapor or steam starts to pass through it and remaining closed as long as there is a vacuum in the system. Condensation in the return-line passes through a Richardson horizontal swinging check valve, shown in Fig. 4, into the boiler. This check valve prevents the return of water direct from the boiler into the return line.

At the supply end of each radiator is placed a Richardson packless, graduated supply valve, as shown in Fig. 5, which is furnished in three sizes.

One feature of the Richardson system which is specially emphasized by its manufacturers, the Richardson & Boynton Company, New York, is that it will operate satisfactorily as either a vapor, a vacuum, or a pressure system. For use with this system they recommend water type radiators, and the same amount of radiation as would be required for a gravity steam system.

(*Concluded on Data Sheet No. 132-EE*)

VAPOR HEATING.

The Richardson System.

(Concluded from Data Sheet No. 132-DD)

The following tables give the pipe sizes recommended by the manufacturers for use with this system. These tables are based on the assumption that no unusual conditions prevail and that the radiation is sufficient to maintain a temperature of 70° F. Emphasis is laid on the need for maintaining proper grades. All lateral pipes and branches should have a grade of at least 1 in. in 2 ft. and both the supply and the return lines mains should have a grade of 1 in. in 20 ft.

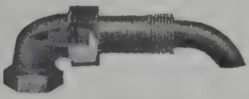
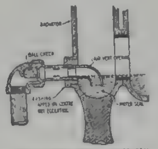
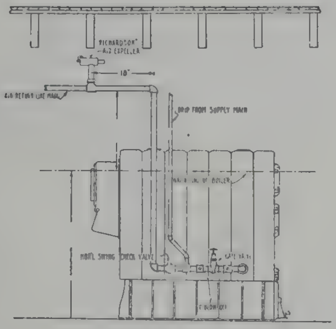


FIG. 2.



SECTION OF BALL CHECK & WATER SEAL

FIG. 3.



RETURN CONNECTIONS AT BOILER

FIG. 4.

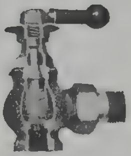


FIG. 5.

Supply mains not exceeding 100 lineal feet in length.

Sq. Ft. Radiation	Pipe Size, In. Diam.
150	1½
400	2
600	2½
1000	3
1400	3½
2000	4

Wet Return Mains

Sq. Ft. Radiation	Pipe Size, In. Diam.
400	1
1000	1¼
1800	1½
5000	2

Air Return Line Mains

Sq. Ft. Radiation	Pipe Size, In. Diam.
80	¾
200	1
800	1¼
1500	1½
4000	2

Risers up to 30 lineal ft. high.

Sq. Ft. Radiation	Sup. Riser In. Diam.	Ret. Riser In. Diam.
20	¾	¾
60	1	¾
100	1¼	¾
180	1½	¾

THE HEATING AND VENTILATING MAGAZINE—1123 BROADWAY, N. Y. CITY

VAPOR HEATING.

The Donnelly Fractional Distribution System.

The primary object in the Donnelly one-pipe and two-pipe fractional distribution systems (Donnelly Systems Co., New York) is to obtain fractional control of the steam supply and to effect distribution to the various radiators under varying weather conditions. In each system the fractional generation of steam is accomplished by means of a regulator (Fig. 3). In addition each radiator is provided with a packless inlet valve (Fig. 4).

In the one-pipe system the air is exhausted by means of a weight-controlled vacuum air valve on each radiator (Fig. 5). Distribution to radiators is obtained by proper selection of pipe sizes and by variously wighting the vacuum air valves. The vacuum attachment to the air valve consists of a tight-fitting cap which contains a valve stem and seat, weighted by means of a number of removable washers. In applying these the maximum number of washers is placed on the air valve nearest the boiler. For other radiators, the rough rule is to remove one washer for each 10 ft. away from the radiator nearest the boiler. This adjusts the weight over the area in each cap so that all air valves will discharge at the same time when the pressure drop in the piping is 1 oz. per 100 ft. of pipe.

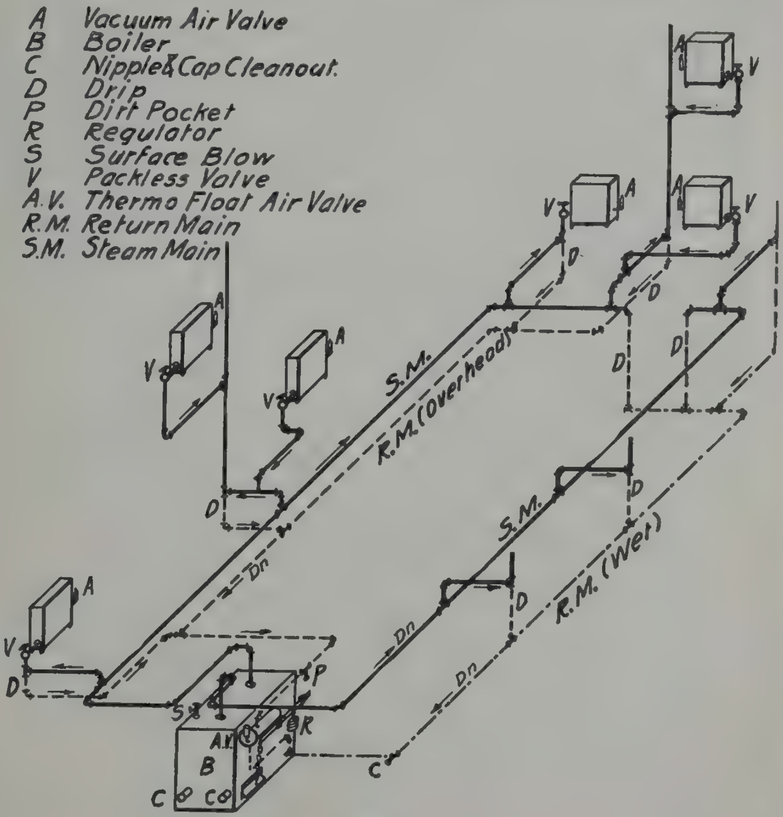


FIG. 1.

(*Continued on Data Sheet No. 132-GG.*)

VAPOR HEATING

The Donnelly Fractional Distribution System.

(Continued from data Sheet No. 132-FF.)

In the two-pipe system, in addition to the packless inlet valve, each radiator is provided with an impulse check valve (Fig. 6) at the outlet, together with thermo-float air valves (Fig. 7) located on the dry return mains before they drop to the wet return.

In neither the one-pipe or two-pipe system is it necessary to pass all the returns through the regulator. A typical set of returns is selected most convenient to the particular layout.

In the one-pipe system the other returns may come back wet, or, where conditions require, overhead and then drop to the wet return.

In the two-pipe system the other returns come back overhead, in groups, vented by means of a thermo-float air valve and then drop to a wet return through which the condensation returns to the boiler.

The fractional distribution inlet valve (Fig. 4) consists of a packless valve with an adjustable key-hole-shaped orifice in both the body and the union. By rotation of the union piece any desired opening may be obtained. The pressure drop through this valve is 2 oz. at maximum rating. Higher pressure drops are obtainable by decreasing the area of the orifice.

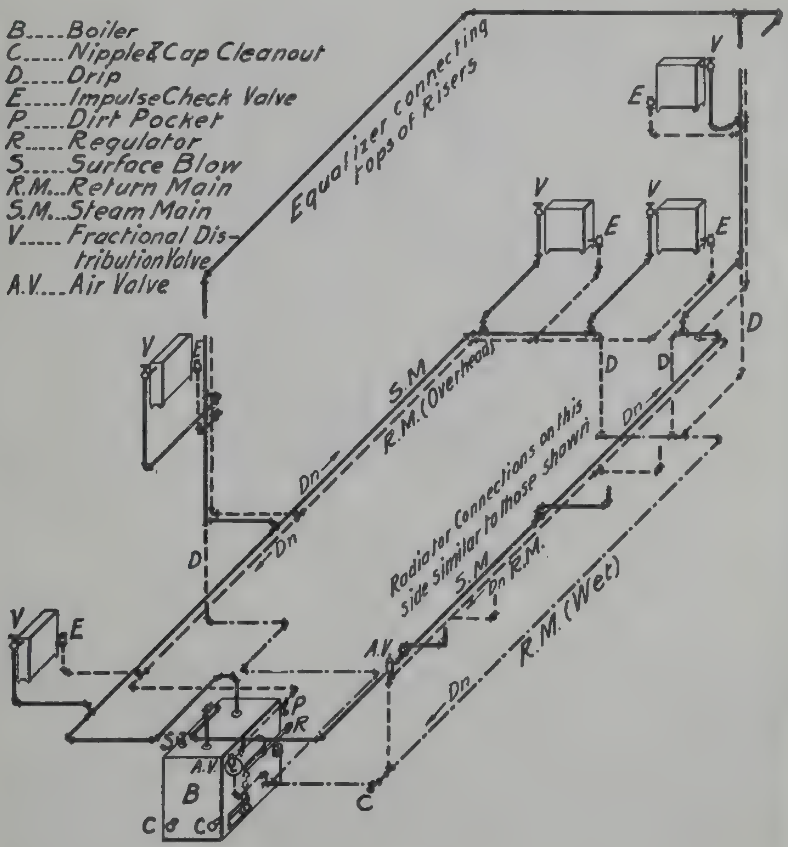

B.....Boiler
C.....Nipple & Cap Cleanout
D.....Drip
E.....Impulse Check Valve
P.....Dirt Pocket
R.....Regulator
S.....Surface Blow
R.M...Return Main
S.M...Steam Main
V.....Fractional Distribution Valve
A.V....Air Valve
Equalizer connecting tops of Risers
V
E
D
Dn
S.M
R.M. (Overhead)
Radiator Connections on this side similar to those shown
S.M.
R.M.
R.M. (Wet)
A.V.
P
R
S
B
C

FIG. 2.

(Continued on Data Sheet No. 132-HH.)

VAPOR HEATING

The Donnelly Fractional Distribution System

(*Continued from Data Sheet No.* 133-*GG*)

OPERATION OF ONE-PIPE SYSTEM.

After adjustment of the regulator and with the building cold, set the weight on the regulator for a higher rate of burning than normal until the building is brought up to temperature. After this, set the weight on the regulator to maintain this temperature. When steam-type radiators are used, the air valves will be cold except in extreme weather since only part of the radiators are heated.

OPERATION OF TWO-PIPE SYSTEM.

The general principle of distribution with the two-pipe system is to have the total pressure drop through pipe, fittings and orifice the same for each radiator. Thus, radiators nearer the boiler have a lower pressure drop through pipe and fittings, but a higher drop through the orifice.

Two methods may be followed in determining the correct orifices. Where the installation requires precise results, the exact method is recommended.* For ordinary-sized installations simple rules, as given by the manufacturer, may be followed. When once adjusted correctly for any one load, the distribution system remains correct for all loads.

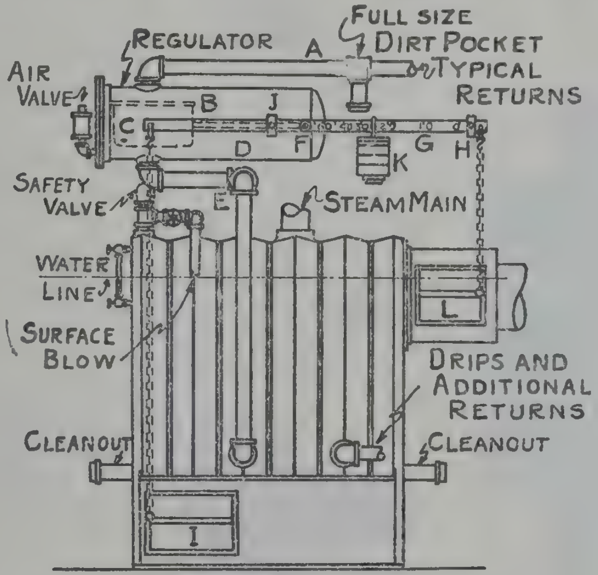


Fig. 3—Typical Installation of Donnelly Fractional Damper Regulator

The Donnelly fractional damper regulator (Fig. 3) is designed on the principle of proportioning the rate of burning to a desired rate of returning condensation. The water of condensation flows through the piping A and drops into the cup B in the body of the regulator. The cup B is provided with an orifice C, near the bottom, from which the water flows into the body of the regulator D. It then returns to the boiler through the pipe E. The cup is supported on an arm which is pivoted at the point F, the spindle of which passes through the stuffing box to the outside of the regulator where it is provided with a lever G, attached to the dampers by chains. The lever is graduated to read outside temperatures so that a weight, K, when set on a notch corresponding to the outside temperature, will cause a predetermined inside temperature to be maintained, as the rate of condensation is insured.

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* Adler and Donnelly on "Fractional Distribution in Two-Pipe Gravity Heating Systems."—Trans. A. S. H. & V. E.

(*Continued on Data Sheet No.* 133-*II*)

VAPOR HEATING

The Donnelly Fractional Distribution System

(*Continued from Data Sheet No.* 132-*HH*)

NORMAL OPERATION OF REGULATOR.

Assume that the building is brought up to the desired temperature. The weight K is first set on the notch numbered the same as the outside temperature. At the rate of burning then existing, the condensation is returning to the cup at a certain rate. This will build up a head of water in the cup until the rate of outflow just equals the rate of inflow. In this position the lever is in balance by the proper location of the lever K. This is the method of locating the position of the notch corresponding to the outside temperature.

Suppose the fire burns down so that less steam is supplied. The condensation will return more slowly and the weight K will overbalance the cup. The lever is then in a position of lifting the chain to the damper I, opening it wider, admitting more air and ultimately increasing the rate of combustion. The new rate of combustion will soon increase the flow of condensation and the cup will overbalance the weight K and close off the damper I and keep it in balance when the head of water is such as to correspond to the rate of burning desired. Should the conditions be reversed, the regulator operates in reverse order.

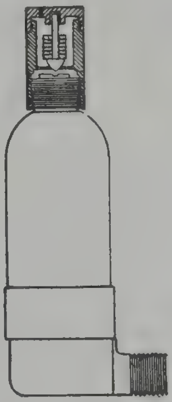


Fig. 5—Weight Controlled Vacuum Air Valve

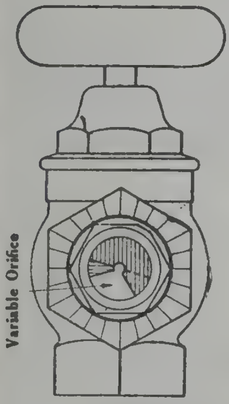


Fig. 4—Packless Inlet Valve

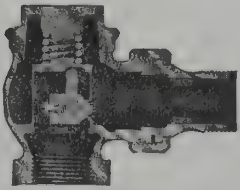


Fig. 6—Impulse Check Valve

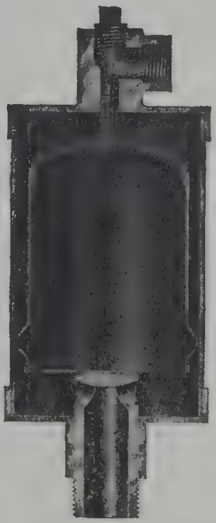


Fig. 7—Thermo Float Valve

The area of the orifice is determined from the radiation connected through the regulator. It is of such size that under maximum load the head of water above the orifice will be less than the height of the cup. This will prevent the overflowing of the cup. When the orifice is determined for these conditions, its area remains constant for partial loads, the variations in the flow being obtained by variations in the head of water in the cup.

The regulator is made in two sizes. The smaller is used on systems not exceeding 500 sq. ft. and the larger on systems over 500 sq. ft. For the smaller size it is desirable to have condensation from 200 to 300 sq. ft. and for the larger from 300 to 500 sq. ft. pass through the regulator.

(*Concluded on Data Sheet No.* 132-*JJ*)

VAPOR HEATING

The Donnelly Fractional Distribution System

(Concluded from Data Sheet No. 132-II)

CAPACITIES OF PIPES, ONE-PIPE SYSTEM.

(Square Feet of Radiation).

Nominal Diameter of Pipe, In.	Steam Main and Down-Feed Risers	Up-Feed Risers	Radiator Connections	Wet Drip Main	Dry Drip Main and Regulator Returns
1	40	40	24	1600	500
1¼	75	75	60	3000	1000
1½	150	125	100	6000	2000
2	300	280	200	....	4000
2½	500	460	....	....	7000
3	900	670	....	....	....
3½	1500	900	....	....	....
4	2000	1200	....	....	....
4½	2800	1500	....	....	....
5	3600	....	....	....	....
6	6000	....	....	....	....

PIPE SIZES FOR DRIPS FROM STEAM RISERS.

(One-Pipe Systems).

Inches Diameter.

Steam Riser	1	1¼	1½	2	2½	3	3½	4	4½	5	6
Drip to Wet Return	¾	¾	¾	1	1	1	1¼	1¼	1¼	1½	1½
Drip to Dry Return	¾	¾	1	1	1¼	1¼	1½	1½	2	2	2½

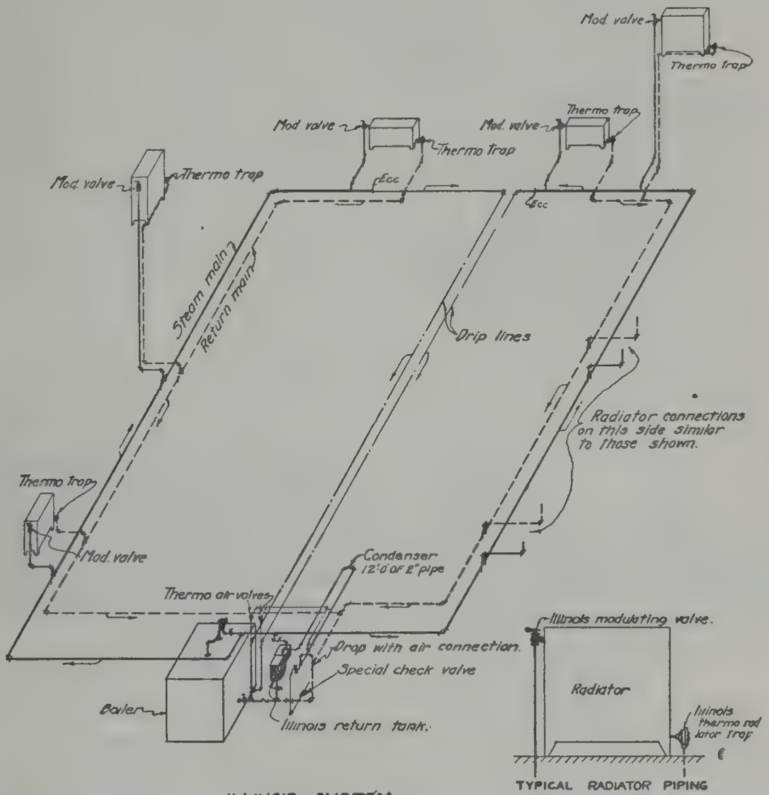
CAPACITIES OF PIPES, TWO-PIPE AIR RETURN SYSTEMS.

(Square Feet of Radiation.)

Nominal Diameter of Pipe, In.	Steam Mains and Risers	Wet Return	DRY RETURNS.			
			Main Return and Regulator Returns	Return Riser	Radiator Connections	Size of Drips, In. Diam.
½	....	....	....	....	50	....
¾	20	800	...	200	100	....
1	40	1600	500	400	200	....
1¼	75	3000	1000	800	400	¾
1½	150	6000	2000	1500	....	¾
2	300	12000	4000	3000	....	¾
2½	500	20000	7000	5000	....	1
3	900	36000	12000	....	....	1
3½	1500	60000	20000	....	....	1
4	2000	80000	27000	....	....	1¼
4½	2800	....	37000	....	....	1¼
5	3600	....	48000	....	....	1¼
6	6000	....	80000	....	....	1¼
7	9000	....	....	....	....	....
8	13000	....	....	....	....	....
9	18000	....	....	....	....	....
10	23000	....	....	....	....	....
12	37000	....	....	....	....	....
14	55000	....	....	....	....	....
16	78000	....	....	....	....	....

VAPOR HEATING

The Illinois System



—ILLINOIS SYSTEM—

FIG. 1.

The Illinois Vapor system has been developed by the Illinois Engineering Company, Chicago, Ill., one of the pioneers in this field. It can be or is operated below atmospheric pressure for hours at a time, but is also to be classed as a modulating system, the radiators being equipped with quick-opening supply valves (Fig. 2) which gives a range from full steam to no steam on a half turn of the handle.

The Illinois system includes specialties or appliances which are designed to take care of any condition of pressure or vacuum which are possible in a low-pressure heating system. These include a return trap (Fig. 3) which operates automatically to put the water of condensation back into the boiler, regardless of the boiler pressure, up to a limit of 10 lbs. pressure, the limit of low-pressure heating boilers.

All of the radiators are equipped with the Illinois Thermo trap (Fig. 4) which discharges the air and condensation into the return mains which run to the return trap. Quick heating up of the system is made possible by the Thermo trap which provides a 5/16-in. air outlet on each radiator.

The air vent from the return trap, which also acts as an air-liberating tank, is provided with an air vent seal valve which is described as the result of twelve years' experience with this type of heating system. It permits the air to be vented from the system on 2 or 3 oz. of pressure. Care must be taken in its use to see that it prevents the air from pulling back into the system when the pressure in the system falls below atmospheric pressure—that is, when the system is operated as a vapor system.

The ends of the steam mains are dripped into a separate wet return which is carried back to the boiler without passing through the return trap. In the arrangement of overhead supply systems, an Illinois vent seal valve is usually placed at the high point on the supply mains.

(Continued on Data Sheet No. 132-LL)

VAPOR HEATING

The Illinois System

(Concluded from Data Sheet No. 132-KK)

Sizes, Capacities of Illinois Modulating Valves

SIZE In. Dia.	Capacity Sq. Ft. Direct Radiation	C Inlet to Face In.	C Tail-piece to Face In.	Wt. Lbs
¾	100	2⅝	1⅜	2
1	200	3⅛	1-9/16	2¾
1¼	275	3½	1¾	4½
1½	400	4	2	4¾

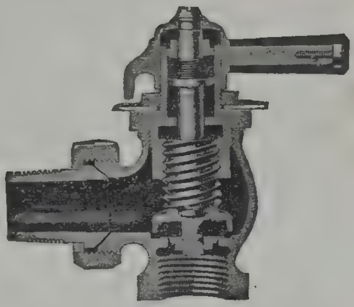


FIG. 2.—ILLINOIS THERMO MODULATING VALVE

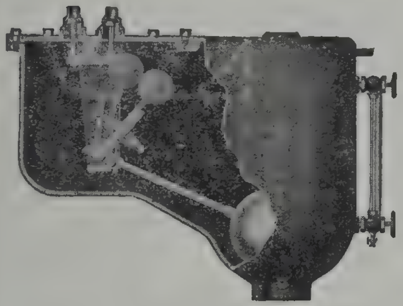


FIG. 3.—ILLINOIS RETURN TRAP.

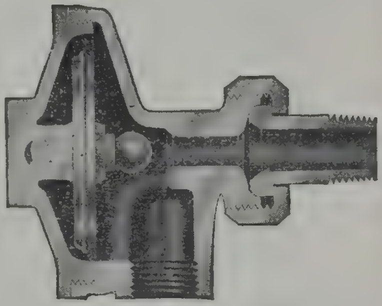


FIG. 4.—ILLINOIS THERMO RADIATOR TRAP

Sizes, Capacities, Dimensions of Illinois Thermo Radiator Trap

SIZE In. Diam.	Capacity Sq. Ft. Direct Radiation	Pipe Connections In. Diam.	WEIGHT Lbs.	Center Outlet to end of Spud, In.	Center Spud to Face of Outlet In.
½ (Junior)	75	½	2½	2½	1¾
¾	500	¾	4	2¾	2-7/16
1	1500	1	17	1¾	3¼
½ (Standard)	200	½	3	2½	1¾

PIPE SIZES—RADIATOR TAPPINGS

MAINS			RISERS			Horizontal Supply Branches Mains to Risers		Horizontal Return Branches Mains to Risers	
Supply	Radiation	Return	Supply	Radiation	Return	Supply	Radiation	Return	Radiation
2"	400 sq. ft.	1¼"	¾"	40 sq. ft.	¾"	¾"	20 sq. ft.	¾"	60 sq. ft.
2½"	700 "	1½"	1"	80 "	¾"	1"	60 "	1"	350 "
3"	1,250 "	1½"	1¼"	150 "	1"	1¼"	110 "	1¼"	1,700 "
3½"	2,000 "	1½"	1½"	220 "	1"	1½"	160 "		
4"	3,000 "	2"	2"	500 "	1"	2"	400 "		
4½"	4,300 "	2½"	2½"	900 "	1¼"	2½"	700 "		
5"	5,600 "	2½"	3"	1,500 "	1¼"	3"	1,100 "		
6"	9,000 "	3"	3½"	2,100 "	1¼"	3½"	1,800 "		
7"	14,000 "	3½"							
8"	19,000 "	4"							

Tappings for Radiators
¾"x½" up to 100 sq. ft.
1 "x½" up to 150 sq. ft.
1¼"x¾" over 200 sq. ft.

VAPOR HEATING

The O-E Perfect System.

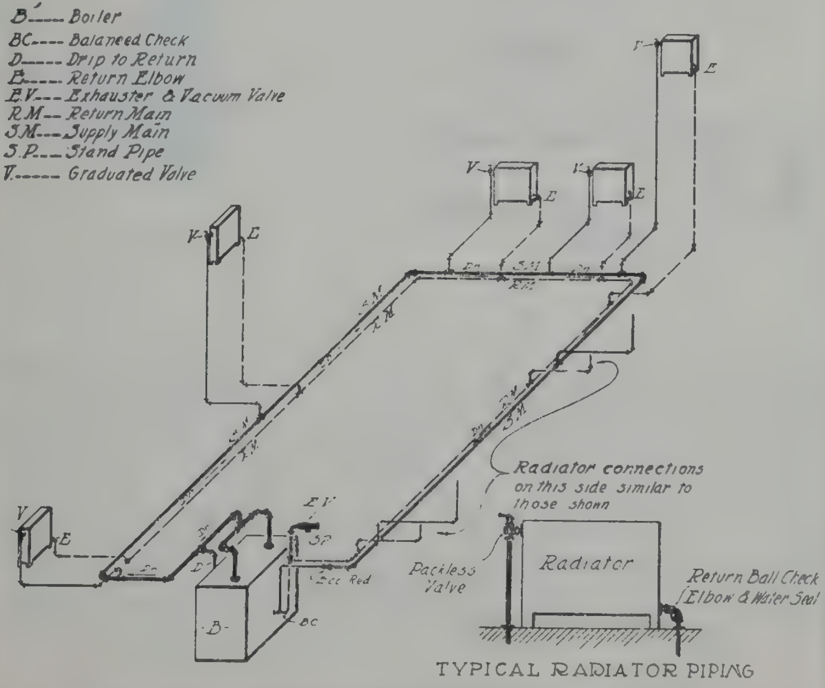
In the design of the O-E Perfect vapor system, every effort has been made to reduce the number of parts to the fewest possible. As will be seen from Fig. 1, the special devices used are limited to packless graduated radiator valves, water-seal ball-check union elbows on the radiator returns and a combined air exhauster and vacuum valve located on the return main near the boiler.

Vapor generated in the boiler passes up through the main supply pipe to the several radiators through small individual supply pipes from the main. The vapor is admitted to each radiator at the top through an O-E packless graduated valve. As the vapor condenses in the radiator, the water of condensation falls to the bottom of same and is returned to the boiler through a ½-in. O-E elbow connected into a ½-in. pipe, thence into the main return pipe in the basement.

In passing through the elbow the water is first trapped by a wall or diaphragm, cast in the elbow outside of the radiator (Fig. 3) making a water seal which is designed to hold the vapor in the radiator and to prevent it from short-circuiting into the return main.

To avoid water being drawn back into the radiators when the supply valve at the top of the radiators is closed, provision is made in the O-E elbow to avoid this trouble by equipping it with a small bronze ball operating on a smooth guide or track and arranged so that when a vacuum is formed in the radiator the ball will immediately roll against the port and prevent water from being drawn into the radiator from the return pipe. Noiseless operation is secured by having the water seal below the ball. The opening of the supply valve at the top of the radiator causes the ball in the elbow to roll off its seat, permitting condensation and air to pass into the return main. An air vent is tapped in the adjustable screw top of the return elbow to allow the air to escape freely into the return system when the supply valve is open and also to equalize the pressure on both sides of the water seal, thus preventing it from siphoning out.

(Continued on Data Sheet No. 132-NN.)



~O.E. VAPOR-VACUUM-PRESSURE SYSTEM~

VAPOR HEATING

The O-E Perfect System.

(Concluded from Data Sheet No. 132-MM).

All air and condensation pass through the main return pipe in the basement to a point above the boiler where the air is separated from the water. Air passes up and through the O-E exhauster (Fig. 4) into the chimney flue or any place desired, while the water returns to the bottom of the boiler.

The O-E air exhauster and vacuum valve is connected at a high point above that where the return main drops down to the return opening in the boiler. The exhauster remains open while there is any air in the system. As soon as vapor comes into contact with the carbon post in the exhauster, the post expands and forces a hollow bronze ball against the seat, closing the port. When closed the system will cool slightly, causing a vacuum to form and this will hold the ball on the seat of the exhauster as long as there is a vacuum in the system. As soon as the vacuum is broken, on account of air getting into the system, the ball will roll away from the seat in the exhauster, again permitting the air to escape.

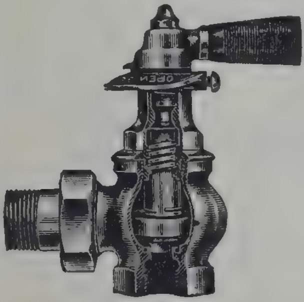


Fig. 2—O-E Packless Valve.

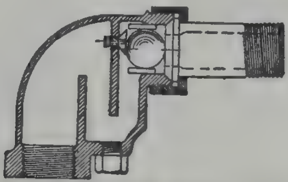


Fig. 3—O-E Ball-Check Water-Seal Return Fitting.

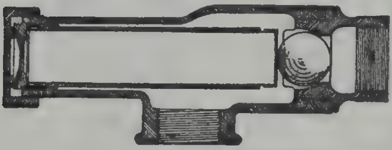


Fig. 4—O-E Air Exhauster

Means to make the exhauster fool-proof are taken by having a brass shell or reinforcement around the carbon post, with a brass cap over the end of the post, to prevent the post from getting out of shape if, for instance, it should be screwed down against the seat when cool. The cap locks the expansion post after it is properly adjusted. All exhausters are set for ordinary use, but can be adjusted to suit any particular system to which they are attached. They are threaded 1 in. both inlet and outlet.

The O-E packless valve (Fig. 2) used with this system is of the quick-opening type, requiring one-half turn to completely open it. Its handle is made of hard rubber and has a graduated dial and pointer. The dial is cast on an angle so as to be easily read from some distance.

The ball-check water-seat union elbow is made in one size only, ½-in., and the air exhauster and vacuum valve is also made in but one size, 1-in. The O-E packless graduated valve comes in four sizes, ½-in., ¾-in., 1-in. and 1¼-in. The system is manufactured by the O-E Specialty Mfg. Co., Milwaukee, Wis.

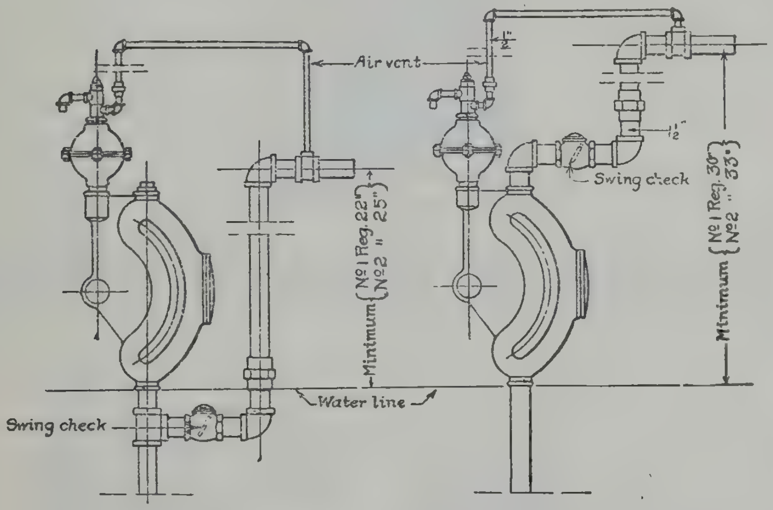
VAPOR HEATING

The Simplex System

The distinguishing feature of the Simplex modulating system is the use of the Wiley "safety-vent" vapor regulator (Fig. 1), which is applied to the boiler for properly regulating the draft and boiler pressure, also for controlling the vent outlet from the air return line mains. The regulation and control is intended to provide a safeguard against damage to the boiler by the discharge of water through the vent opening, in case of an accidental rise in pressure beyond the ordinary safe limits.

With this equipment boilers are fitted with regular low-pressure safety valves, as for ordinary steam heating work. In case the steam pressure should rise, the heat is stored up in the form of pressure. This arrangement also acts to prevent the loss of water in the escape of vapor. The other specialties that make up the Wiley system are the Wiley calibrating radiator valve (Fig. 2) and the water-seal trap (Fig. 3).

To make clear the operation of the "safety-vent" vapor regulator it may be stated that it consists of a semi-circular cast-iron float chamber, with threaded outlets at top and bottom for connecting into the vertical return pipe at one side of the boiler. The casing is also threaded to receive a brass float stem bonnet and stuffing box, as well as the brass vent valve casing at the top.


Air vent
Minimum {No 1 Reg. 22" / No 2 " 25"}
Water line
Swing check
1/2"
1/2"
Swing check
Minimum {No 1 Reg. 30" / No 2 " 33"}

TYPE "B"

Special connection for air return mains over 2½" or those limited to less than 25" above water line.

TYPE "A"

Standard connection up to 2½" air return main with 30" or more elevation above water line.

Typical Installations of Wiley "Safty-Vent" Regulator

Inside the float chamber is a copper float attached to a float arm carried by a spindle extending through the bonnet and stuffing box. The float spindle carries a combination pointer and damper-operating lever, and has a series of holes for attaching the damper-operating cables, so spaced that any desired movement of the dampers may be obtained.

The regulator is equipped with an independent float-actuated "safety-vent" valve,

(Continued on Data Sheet No. 132-~~OO~~ PP).

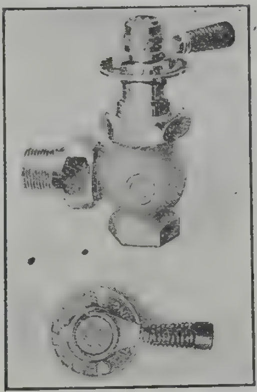
VAPOR HEATING

The Simplex System

(Continued from Data Sheet No. 132-NN)

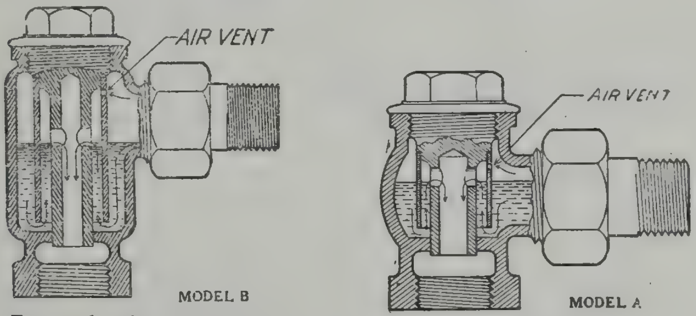
through which the air is discharged from the heating system. This valve, with its spherical float chamber, is mounted directly on top of the regulator casing. In case of accidental rise in pressure, the copper float operates to close the valve outlet.

The regulator is placed above the water-line in the boiler and the damper-operating arm connected to both the check and draft dampers.



Calibrating Radiator Valve.

In operation, the air and condensation from the heating system pass through the float chamber on their way to the boiler, the air passing out through the vent valve to the top of the casing, while the water descends to the boiler by gravity. The generation of steam in the boiler produces a downward pressure on the surface of the water, forcing it up into the float chamber. This action carries the float upward and also raises the damper-operating lever and pointer, incidentally indicating the pressure in ounces on the graduated scale on the side of the float chamber, while operating the dampers by means of the chains.



For work where horizontal pipe connections do not have to be made above floors.

For use where pipe connections are run above floors.

TYPES OF WATER-SEAL TRAPS USED WITH SIMPLEX SYSTEM

The manipulation of the dampers acts to retard the rate of combustion and to control the generation of steam, so as to hold it within the desired operating range of a few ounces.

(Continued on Data Sheet No. 132-PP)

VAPOR HEATING

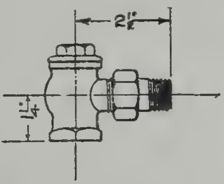
The Simplex System

(Concluded from Data Sheet No. 132-00)

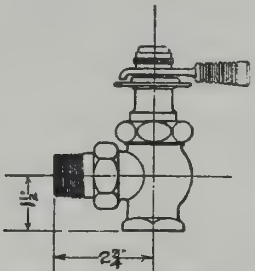
In case of an accidental rise in pressure and the elevation of the water beyond the range of the float chamber the "safety-vent" valve will be closed when the float reaches its extreme upward movement, and thus prevent the discharge of water through the vent opening.

The return line is provided with a swing check valve located just above the regulator to prevent the water from being forced into the return line during such a rise in pressure. The check valve is provided with a by-pass connected into the "safety-vent" valve in such a way as to allow a free passage for the outgoing air during the normal operation of the apparatus, without overcoming the resistance of the check valve in the return line.

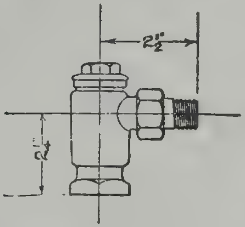
The calibrating radiator valve (Fig. 2) gets its name from the fact that it has a calibrating feature or capacity adjustment, so designed that its capacity can be permanently adjusted to meet the demands of any size radiator. This is effected by changing the position of a calibrating plug located inside of the valve member so as to project more or less into the main port opening. The adjustment is made before placing the valves on the radiators by inserting a screw-driver through the bottom of the valve body into the slots in the lower end of the calibrating plug and turning the plug to the right the number of turns given in the following table.



MODEL "A" TRAF



CALIBRATING VALVE



MODEL "B" TRAP

Roughing-in Dimensions of Wiley Calibrating Valve and Water-Seal Traps.

Square Feet Radiation	Number of Complete Turns to Be Given Plug.
10 to 15	1
15 to 20	2
20 to 30	3
30 to 45	4
45 to 60	5
60 to 80	6
80 to 100	7
100 to 125	8
124 to 150	9

The above rule is approximate for pressure up to 6 oz., as ordinarily used in connection with atmospheric or vapor systems.

The temporary regulation or graduation of the heat supply is obtained by moving the pointer between the open or "on" and the closed or "off" position on the graduated dial plate. This regulation, it should be noted, is entirely independent of the permanent adjustment or calibrating feature of the valve, and is effective at any permanent adjustment.

The Simplex system is manufactured by the Simplex Heating Specialty Co., Inc., Lynchburg, Va.

VAPOR HEATING.

The Dual System.

The dual system derives its name from the fact that a typical installation, as shown in Fig. 1, may be operated as a vapor system or with pressure. The term vapor, as used by the manufacturers of this system, refers to atmospheric pressure, or within an ounce or two of atmosphere, while the term pressure refers to above 1 lb. gauge. An additional factor relative to the name of the system, is the use of a Dual valve on each unit of radiation, and at drip points.

The manufacturers do not advocate dripping the supply main to the return through traps or otherwise if possible to avoid such an arrangement. All Dual systems are designed to permit the supply main to be carried back to the boiler, and venting is provided for at that point.

When operated as a vapor or atmospheric system, the Dual boiler return trap (Fig. 4) does not function except to co-operate with the Dual air eliminator (Fig. 5) to permit the exit of air from the system. Under this condition, the condensation returns to the boiler by gravity. If the pressure is created on the system the Dual boiler return trap is forced to function automatically by the returning condensation.

One of the primary factors assisting in the operation of the Dual system is the use of the Dual air eliminator on the end of the return main, ahead or in front of the Dual boiler return trap. This eliminator is designed to permit the unrestricted elimination of air, when operating near atmospheric pressures, and, when operating under pressure, to relieve to a large extent the duty of the boiler return trap in eliminating air from the system. The outlets of vents on drip mains are connected to the air eliminator so as to prevent air from being drawn back into the system.

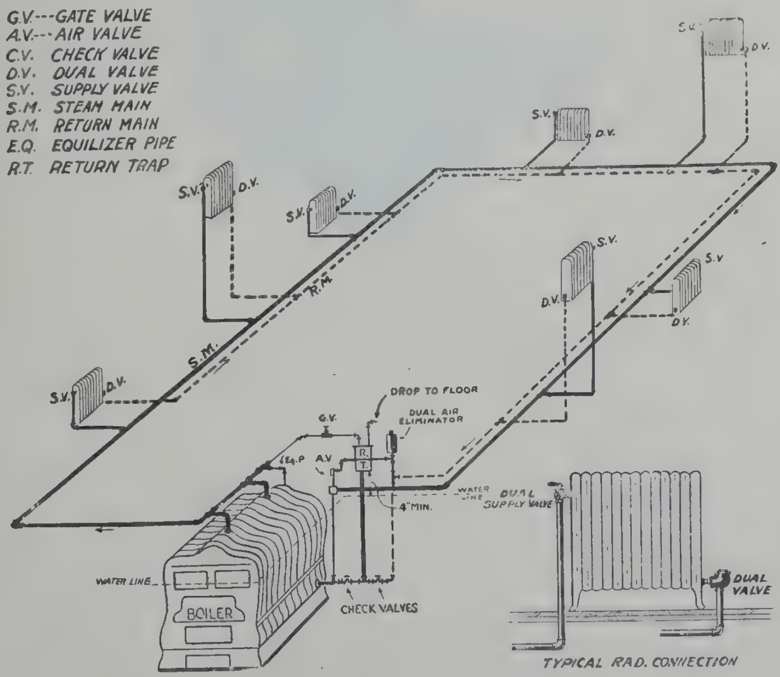


Fig. 1. The Dual System.

(*Continued on Data Sheet No. 132-SS*)

VAPOR HEATING.

The Dual System.

(*Continued from Data Sheet No. 132-RR*)

In addition, a metal diaphragm damper regulator is provided to give positive and sensitive control of the boiler pressure.

The general system of piping employed with a Dual system does not differ radically from other vapor systems, with the exceptions noted. The Dual valve, it will be noticed, is installed on the return end or the outlet, and the Dual graduated supply valve on the inlet of each radiator of the system.

As will be seen from Fig. 2, the operation of the Dual valve is almost self-explanatory. When installed the float is down in which position it holds in place the valve at the outlet opening. A hollow valve stem is used for the elimination of air, care also being taken to provide an area as large as the inlet of the ordinary thermostatic trap.

It is not necessary for condensation to collect in the trap body and raise the outlet valve to permit the air to make its exit. When all air has passed through the hollow valve stem, the steam or vapor naturally follows. When this steam or vapor comes in contact with the bi-metallic strip at the top of the valve stem, it acts to prevent the passage of the steam or vapor to the return line. The Dual valve now operates purely as a float valve and is governed only by condensation and not temperature.

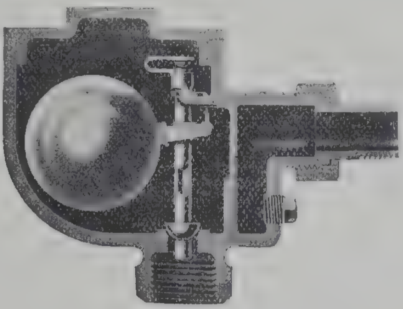


Fig. 2—The Dual Valve.

CAPACITIES AND SIZES OF DUAL VALVE

Size, In. Diam.	Capacity Sq. ft. Direct Radiation.	Center Outlet to End of Spud, In.	Center Spud to Face of Outlet, In.	Pipe Connection In. Diam.
½	200	3 ¼	2 ½	½
¾	500	3 ½	2 ¾	¾
1	1400	4	3 ¼	1

As the steam or vapor condenses in the radiator or other vessel, it flows into the Dual valve, causing the float to rise and permitting the condensation to flow to the return pipe. As condensation continues to form, the Dual valve operates as a continuous float trap with water seal. In this way the air and condensation are eliminated simultaneously. When steam or water is shut off from the radiator or other vessel, the Dual Valve acts to permit all water to make its exit and again the float drops to the bottom of the valve, closing the seat at the outlet. The importance of this feature will be apparent where there is likelihood of freeze-ups. The point is also made that the bi-metallic strip and hollow valve stem constitute a trap by themselves, in the event that the float mechanism should cease to function. It is to be noted that the Dual valve is made without the use of solder, diaphragm or volatile liquid.

The Dual boiler return trap is designed to perform all the functions of any reliable direct boiler return trap in relieving all air from the heating system and in returning the water of condensation to the boiler, regardless of pressures up to 20 lbs. The vacuum which it creates in this process is depended upon to aid the rapid circulation of steam or vapor throughout the system. The water of condensation flows by gravity into the trap, lifting a float which serves to automatically close the air relief valve and to open the steam valve, admitting boiler pressure to the top of the trap. The pressure in the boiler and in the trap being thus equalized, the water in the trap passes into the

(*Concluded on Data Sheet No. 132-TT*)

VAPOR HEATING.

The Dual System.

(Concluded from Data Sheet No. 132-SS)

boiler and the receding float then closes the steam port. At this point the steam contained in the trap condenses and creates a vacuum which hastens the return of more air and water. After all the air has been expelled, the Dual boiler return trap is depended upon to maintain a vacuum on the return lines.

The Dual system is manufactured by the Heating & Power Appliance Company, of Milwaukee, Wis., and is described as the result of many years of effort on the part of the company's engineering department.

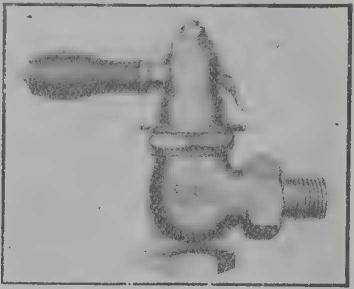
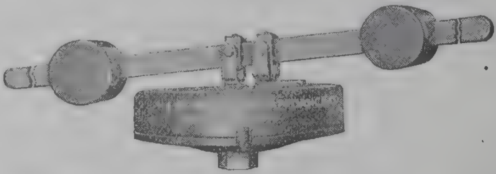


Fig. 3. Dual Graduated Supply Valve.

CAPACITIES AND SIZES OF THE DUAL GRADUATED SUPPLY VALVE

Size, In. Diam.	Capacity Sq. ft. Direct Radiation.	Center Outlet to End of Spud, In.	Center Spud to Face of Outlet, In.	Connection Pipe In. Diam.
½	30	2 ¼	1 3-16	½
¾	100	2 ½	1 3-16	¾
1	200	3	1 ½	1



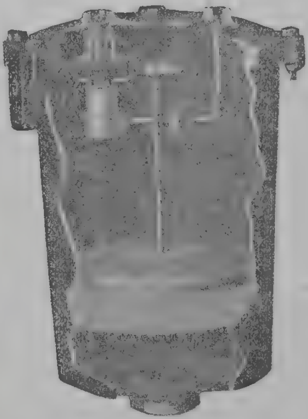
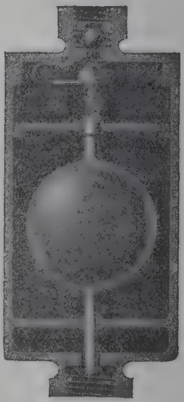


Fig. 4 (at left) Dual Boiler Return Trap.

Fig. 5 (at right) Dual Air Eliminator.

Fig. 6 (above) Dual Damper Regulator.



WATER HEATING—GRAVITY.

General.

The catalog ratings of water heating boilers are based on the number of square feet of direct water radiation, under still air conditions, that the boiler is capable of supplying under the following conditions of operation:

Fuel—Anthracite nut size.

Temperature of water in the boiler 180° F. No loss of heat by radiation from mains.

The fuel-holding capacity of the fire-pot is assumed to hold a charge sufficient to operate the boiler at rated capacity for eight hours, with 20% left to ignite the fresh charge.

Each square foot of radiation is assumed to emit 150 B. T. U. per hour.

Boiler Rating Required:—To allow for the additional tax on the boiler due to loss of heat by radiation from the piping, for handicap of inferior coal and extra load on the boiler when heating up a cold building approximately 50% to 60% should be added to the amount of total direct radiation installed to ascertain the boiler rating required.

General:—The actuating head, causing the circulation, in a gravity water heating system is due to the difference in weight in the water in the flow and return risers. The water supplied to the radiator is cooled by the heat emission of the radiator and will ordinarily leave 10° to 20° cooler, with an increase in density, over that of the supply riser, thus creating a slight circulating or actuating head and corresponding flow through the system.

A water heating system must be supplied with an expansion tank to provide for the expansion and contraction of the water due to the change of temperature.

The increase in the volume of water from 40° to 212° F. is approximately 4.2% so that for every 23 gal. of water in the system an allowance of at least 1 gal. must be made in the expansion tank—practically a 2-gal. allowance should be made.

Cast-iron radiators have an internal volume of approximately 1½ pints per square foot of rating, and steel radiators and steel pipe hold about 1 pint per square foot rating.

The internal volume of the radiation is generally assumed to be about 50% of the total volume in the system.

Classification of Systems:—Gravity systems are classed as either up-feed systems, with basement mains, or down-feed systems, with overhead mains run in the attic or on the ceiling of the top floor.

The up-feed system may have either a one-pipe basement main or a two-pipe main.

The down-feed system may have either single or double risers.

The down-feed system is somewhat more positive in action, permits the use of smaller risers and provides for the automatic removal of the air from the system.

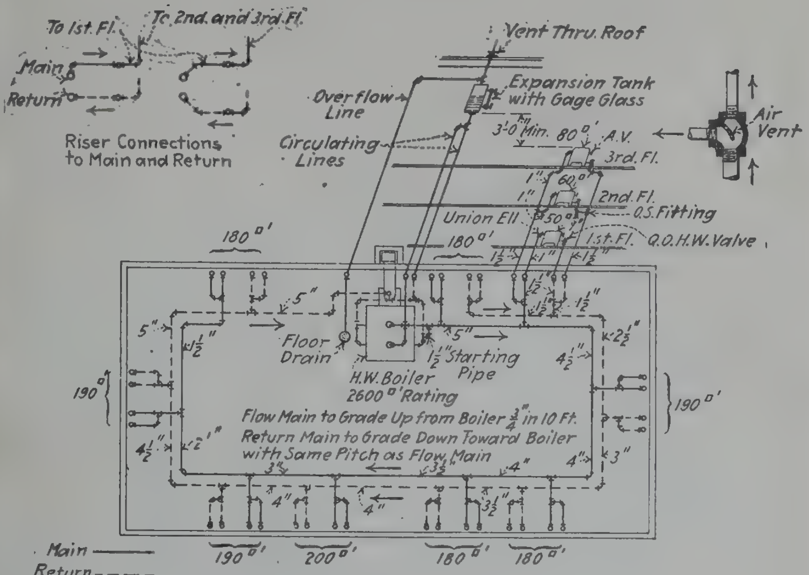
Under-feed systems are liable to prove defective for single-story structures as the motive head is very small.

The up-feed system, with one-pipe main in basement, is popular and in quite general use.

Either system may be operated with an open expansion tank or with a pressure generator.

WATER HEATING—GRAVITY.

Two-Pipe Up-Feed System.



Two Pipe Up Feed System with Reversed Return

FIG. 1.

The basement plan for a two-pipe up-feed system in shown in Fig. 1. The flow and return pipes and run close to basement ceiling, the flow main grading up from the boiler and the return down toward boiler. The mains are graded ¾-in. in 10 ft. This system should be installed with a reversed return, as shown, in order that the water travel and resistance to flow for each group of radiators is practically the same. Each group of radiators will then warm up at practically the same rate.

The sizes of mains may be taken from Table 1 and branches from Table 2. The main sizes are reduced or increased as rapidly as the change in radiation will permit. In using the tables all mains should be measured back to the boiler, and the risers to any floor are proportioned to supply all the radiation above that floor, as well as the radiator installed on the floor.

A starting pipe installed between the flow main and return near boiler is intended to assist in establishing an initial circulation between the two mains. This pipe varies in size from 1¼-in. diam. in small plants to 2½-in. in large installations.

The branch connections for the second and third floors may be taken off the side of riser branches serving the first floor in order to augment the circulation in the first floor radiators. The branch is usually run full size over to the riser to first-floor radiator in order to favor the lowest radiator.

Connections to radiators for the supply should be made at the top, using a union elbow. The return connection is made at the bottom and should be equipped with a quick-opening water radiator valve, with union connection. Only one valve is required to control the radiator with this arrangement.

Each radiator is equipped with an air valve usually of the key type.

O. S. fittings should be used for the branch connections from second floor radiators to risers.

Sizes of expansion tanks are given in Table 3.

When the main is reduced in size at any point an eccentric fitting should be used to keep the top of the large and small mains in the same place and to avoid air pockets.

Free and complete drainage of the system must be provided for, so that when draw-off cock is opened at the boiler the entire system can be emptied of water.

(*Continued on Data Sheet No. 133-B.*)

WATER HEATING—GRAVITY.

Two-Pipe Up-Feed System.

(Continued from Data Sheet No. 133-A.)

TABLES 1 AND 2—WATER HEATING—PIPE SIZES—OPEN TANK.

(Up-Feed, With Basement Mains.)

MAINS UP TO 100 FT.

Pipe Size In. Diam.	Direct Radiation Sq. Ft.	Indirect Radiation Sq. Ft.
1¼	135	100
1½	220	135
2	350	225
2½	460	320
3	675	500
3½	850	650
4	1100	850
4½	1350	1050
5	1700	1350
6	3600	2900
7	4800	3900
8	6200	5000
9	7700	6300
10	9800	7900
12	14000	11400

Notes: Length of main must be measured back to boiler. For mains over 100 ft. reduce capacity in the ratio of $\sqrt{\frac{100}{L}}$

BRANCHES AND RISERS

Pipe Size In. Diam.	Floor First	Second	Third	Fourth
	Direct Radiation Sq. Ft.			
¾	30	45	55	70
1	60	75	85	95
1¼	110	120	135	150
1½	180	195	210	230
2	290	320	350	370
2½	400	490	525	550
3	620	650	690	730
3½	820	870	920	970
4	1050	1120	1185	1250
4½	1325	1400	1485	1560

Notes: First-floor supply riser connections to be taken from top of main and risers above first floor at 45°. All returns into side of main or bottom. (See detail, Fig. 1.)

TABLE 3.—WATER HEATING—EXPANSION TANKS.

EXPANSION TANKS

No.	Size in Inches	Capacity Gal.	Radiation, Sq. Ft.
0	10 x 20	8	250
1	12 x 20	10	300
2	12 x 30	15	500
3	14 x 30	20	700
4	16 x 30	26	950
5	16 x 36	32	1300
6	16 x 48	42	2000
7	18 x 60	66	3000
8	20 x 60	82	5000
9	22 x 60	100	6000

Note: Galvanized steel, tested at 100 lbs., tapped 1¼ in. top and bottom, and for gauge glass.

These tables by J. J. Hogan to be used for either one or two-pipe work.

WATER HEATING—GRAVITY

One-Pipe Up-Feed System.

This system is in wide use and is generally employed by the U. S. Treasury and War Departments whenever an up-feed system is used.

In this system (Fig. 1) the supply or flow main is started close to the basement ceiling above boiler and grades down with the direction of flow, with a uniform grade of ¾ in. in 10 feet. The main is run full size to supply the total radiation and drops after serving the last radiator.

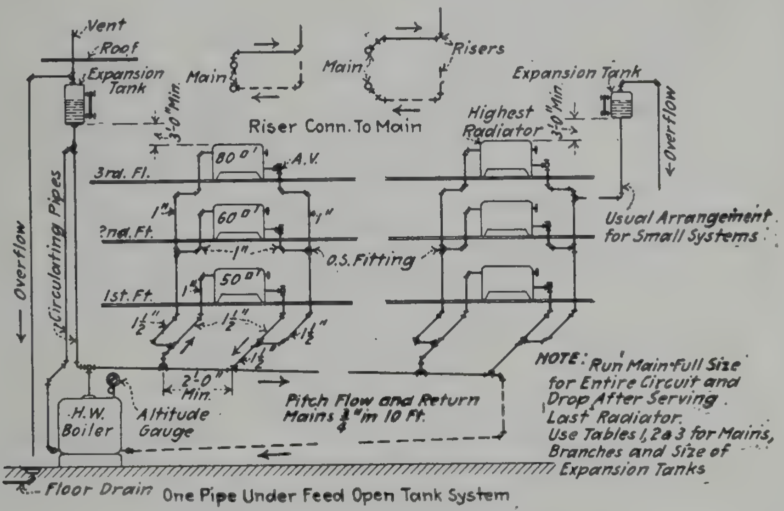

Vent
Roof
Expansion Tank
3'-0" Min.
Main
Main
Risers
Riser Conn. To Main
Expansion Tank
Highest Radiator
3'-0" Min.
Overflow
80 □'
A.V.
3rd. Fl.
1"
60 □'
1"
2nd. Fl.
1"
O.S. Fitting
Usual Arrangement for Small Systems
50 □'
1st. Fl.
1"
1½"
1½"
1½"
1½"
Overflow
Circulating Pipes
2'-0" Min.
NOTE: Run Main Full Size for Entire Circuit and Drop After Serving Last Radiator. Use Tables 1, 2 & 3 for Mains, Branches and Size of Expansion Tanks
H.W. Boiler
Altitude Gauge
Pitch Flow and Return Mains ¾" in 10 Ft.
Floor Drain
One Pipe Under Feed Open Tank System

FIG. 1.

The branches are taken from the top of main or at an angle of 45° in the case of branches near the boiler, or for branches supplying only upper-floor radiators.

The return branches are connected unto the side or bottom of main. Pipe sizes are to be taken from Tables 2 and 3. (Data Sheet No. 133-B).

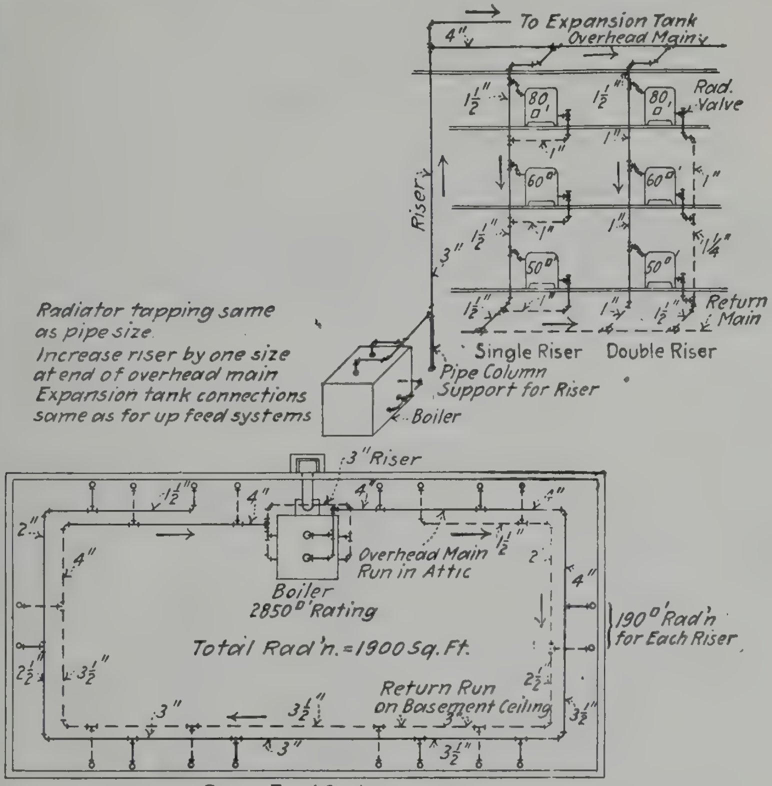
The branch connections for flow and return branches to any group of radiators should not be made closer than 2 ft. measured along the main. Sizes of expansion tanks are given in Tables 3, (Data Sheet No. 133-B).

WATER HEATING—GRAVITY.

Down-Feed Systems.

In the down-feed system (Fig. 1) the flow main, after leaving boiler, is run as a main riser to the attic or top-floor ceiling and run around same as a main. The overhead branches to drop risers are taken from the side or bottom of the main.

The main riser must be firmly supported at the base and is provided with bushed T of twice the size of the main riser at top to act as an enlarged chamber for the rapid separation of air for removal through the vent line to the expansion tank.


To Expansion Tank
4"
Overhead Main
1½"
80□'
1½"
80□'
Rad. Valve
1"
1"
60□'
60□'
1"
Riser
1½"
1"
1"
1¼"
3"
50□'
50□'
1½"
1"
1"
1½"
Return Main
Single Riser
Double Riser
Radiator tapping same as pipe size.
Increase riser by one size at end of overhead main
Expansion tank connections same as for up feed systems
Pipe Column Support for Riser
Boiler
3" Riser
1½"
4"
4"
4"
2"
1½"
4"
Overhead Main Run in Attic
2"
4"
Boiler
2850□' Rating
190□' Rad'n for Each Riser
Total Rad'n.=1900 Sq. Ft.
2½"
3½"
2½"
Return Run on Basement Ceiling
3"
3½"
3"
3½"
3"
3½"

. Down Feed System

FIG. 1.

The flow main in basement uniformly grades up from the boiler to the foot of main riser and uniformly grades down from the riser in the attic. Grade ¼ in. in 10 ft.

If single risers are used, sizes may be taken from Table 1. Proportion each section of the riser for the amount of radiating surface it must serve both as a supply and a return line.

If double risers are used they are made somewhat smaller than the single risers and are proportioned as flow and return risers respectively. See Table 1, Data Sheet No. 133-E.

In the overhead system the pipe sizes for the same amount of radiation on any floor is the same.

(*Concluded on Data Sheet No. 133-E.*)

WATER HEATING, GRAVITY.

Down-Feed System

(Concluded from Data Sheet No. 133-D.)

The overhead flow main decreases in size as the branches are taken off and the return in basement increases correspondingly. See Table 1.

The return is run reversed as shown so that the flow is in the same direction as that of the overhead main and gives equal length of water travel for all radiators.

No air valves on the radiators will be required if the system is properly installed as the air is all removed through the vent line.

Only one valve is required for each radiator if the flow connection is made at the top of radiator and the return at the bottom at the opposite end.

TABLE 1.

Pipe Size In. Diam.	Radiation Sq. Ft. Main Riser	Main
1¼	200	150
1½	350	250
2	600	350
2½	1200	540
3	2000	900
3½	2500	1300
4	3500	1800
4½	4500	2400
5	6000	3200
6	10000	5000
7	12000	7200
8	15000	10000
10		13000
12		16000

DROP RISERS.

Pipe Size In. Diam.	Radiation, Sq. Ft. Single Riser	Double Riser
¾	25	50
1	80	120
1¼	120	200
1½	200	350
2	400	600
2½	750	1200
3	1000	2000

WATER HEATING—GRAVITY.

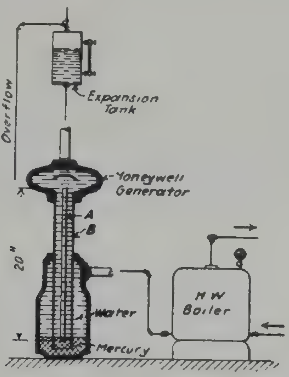
Closed Tank System.

The relation between hydrostatic head, gauge pressure and boiling point degrees F. for water is given in Table 1.

Theoretically it is possible to carry the water in the boiler, with an open-tank system, at a temperature corresponding to the heat as determined by the height of the expansion tank above the boiler. Practically it is not possible to carry a temperature in excess of 212° as the high temperature water will immediately rise into the expansion tank and boil.

In order to be able to increase the water temperature above 212° various devices have been employed. A common form of such apparatus is shown in Fig. 1.

In operation water entering the generator from the system will force the mercury up in the inner tube "A" until a head of 20 in. mercury corresponding to 10 lbs. pressure (240° F.) is established at which time the entrance to this tube will be uncovered by the mercury and water may enter same and pass up to the expansion tank.



Any excess of mercury above that required to just fill the tube "A" is returned by tube "B" to the reservoir in the base.

When the system cools off, water can flow back down tube "A" as soon as the mercury column drops in same, and the slight head of mercury existing at the outlet of this tube is easily overcome by the head of water in the expansion tank above.

The use of a pressure generator permits smaller radiators being used, as it is entirely possible to maintain a temperature as high as steam at 5 lbs. gauge.

Smaller mains and risers can be used with this system the difference between the temperature in the flow and return risers becomes greater with the open-tank systems, and, therefore, a greater actuating head exists.

Since a smaller amount of water is required with this arrangement the system is more sensitive in warming up and also in cooling off.

Table 1—Relation between Hydrostatic Head, Pressure and Boiling Point—(degs. F.).

Head, Ft.	0	12	24	37	49	61	74	87	100
Boiling Point Deg. F.	212	227	239	250	259	268	274	281	287
Press. lbs. sq. in.	0	5	10	15	20	25	30	35	40

Table 2—Sizes of Risers for Honeywell System.

Pipe Size In. Diam.	Capacity Radiation, Sq. Ft. 1st Floor	2nd Floor	3rd Floor
½	30	40	50
¾	75	100	125
1	75UP	100UP	125UP

WATER HEATING, GRAVITY.

Calculations for Small Systems.

For small systems it is often unnecessary to go into much detail for the sizing of the pipes, a common method being to take the valve areas of the valves on the radiator supplies and making the size of main equal to the combined areas of all the values supplied.

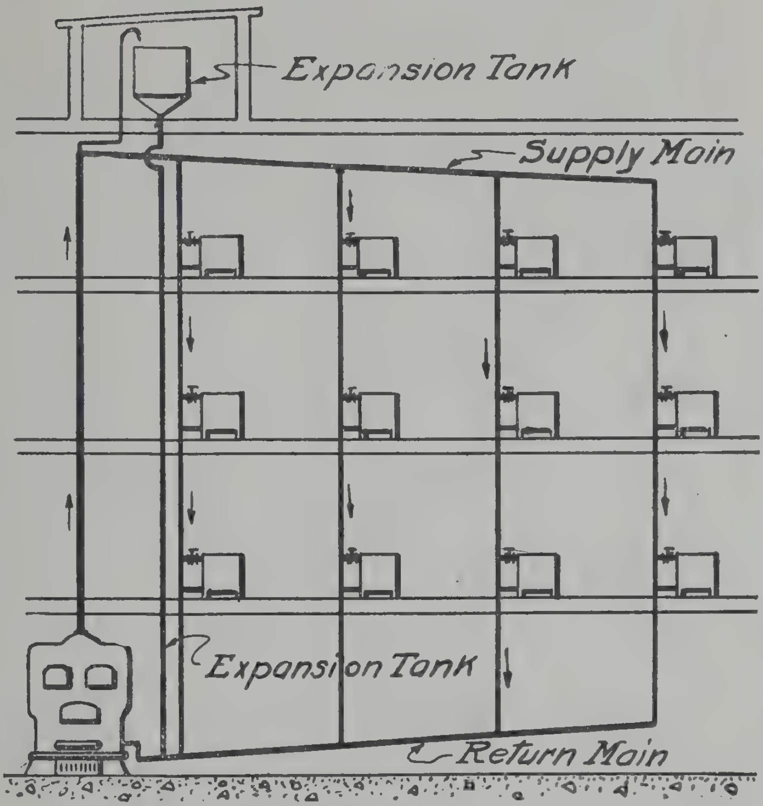
TABLE I

Elevation, Feet		5	15	25	35	45	55	65	75	85
Size of Pioe and Radiator Valve, In. Diam.	3/4	40	50	60	70	80	90	100	110	120
	1	70	80	90	100	110	120	130	140	150
	1 1/4	110	117	135	147	170	187	205	222	240
	1 1/2	180	195	210	230	245	260	275	295	310
	2	300	375	450	500	575	650	700	777	850

NOTE—The above table shows the amount of equivalent direct radiation (E. D. R.) which can be satisfactorily fed at the elevation above the boiler given at the top of each column. "Elevaion" is taken from center line of boiler to center line of radiator. Thus 180 sq. ft. situated 5 ft. above the boiler requires a 1½-in. pipe but at 55 ft. requires only a 1¼-in. pipe.

WATER HEATING—GRAVITY.

One-Pipe Down-Feed System.



The accompanying illustration shows a typical arrangement of a strictly one-pipe water heating system. This system may be installed in only one-way—a down-feed system with an overhead supply main and a bottom return main. The radiators are tapped top and bottom, same end, and have both supply and return tappings connected to the same drop in the manner illustrated. Theoretically the drop should be reduced in size between the radiator supply tee and the radiator return tee in order to shunt some of the flow through the radiator; this feature, however, is often neglected and the difference in the weight of the water in the radiator and the weight of the water in the riser is depended upon to cause a proper circulation in the radiator. This difference in weight is caused, of course, by the cooling and contracting of the water in the radiator as it gives off its heat.

The chief objection to the use of this system is the constant decrease of temperature of the water in the supply drop and in a building of any considerable height this reduction of temperature in the supply (due to the dumping of the radiator returns back into the same pipe) reaches such a serious amount as to make necessary an increase in the surface of the lower radiators to compensate for the cooler water which they receive.

No air valves are necessary as the entire system is vented from the high point at the top of the main supply riser from which point a small vent is run up and turned over above the expansion tank as shown.

This system of piping is probably the cheapest of any water heating system, but is not as satisfactory as the more scientifically designed two-pipe systems.

WATER HEATING—GRAVITY.

Sizing Mains and Risers for One-Pipe Systems.

The sizing of the mains on a one-pipe water heating system may be carried out along the lines of equivalent pipe sizes according to valve areas (Data Sheet No. 133-G) or may be based on the height of the radiators above the boiler.

In the first place, owing to the small amount of head available between the top and bottom radiator connection, the tendency to circulate water into and out of the radiator is not great and the full size standard radiator tapping should be utilized for the runout and valve, in order to assist this circulation all that is possible. This consideration then determines the size of the radiator valve and radiator runout.

The size of the riser may be developed by taking the equivalent size from the following table, although this would best apply on small jobs. The sizes of the mains can then be developed from the risers by the same means.

TABLE I—EQUIVALENT PIPES

NOMINAL SIZES OF PIPES IN INCHES. EQUIVALENT SIZES OF PIPES IN DECIMALS.

½	¾	1	1¼	1½	2	2½	3	3½	4	5	6	8
1.00	2.27	4.88	10.00	15.8	31.7	52.9	96.9	140	205	377	620	1292
	1.00	2.05	4.30	6.97	14.0	23.3	42.5	65	90	166	273	569
		1.00	2.25	3.45	6.82	11.4	20.9	30	44	81	133	278
			1.00	1.50	2.70	5.25	9.1	12	19	32	68	110
				1.00	1.26	3.34	6.13	9	13	23	39	82
					1.00	1.67	3.06	4.5	6.5	11.9	19.6	40
						1.00	1.82	2.70	3.87	7.12	11.7	24
							1.00	1.50	2.12	3.89	6.39	13.3
								1.00	1.25	2.50	4.25	9.0
									1.00	1.84	3.02	6.3
										1.00	1.65	3.4
											1.00	2.1
												1.0

Example—Assume six risers each with three radiators; top radiator 100 sq. ft., middle radiator 70 sq. ft., bottom radiators 40 sq. ft., to determine pipe sizes of valves, radiator runouts, drops, and main at boiler.

As this is a one-pipe system all radiator runouts and valves will be full size of standard tappings or as follows:

Size of Radiator. Sq. Ft.	Std. Tapping. Inches Diam.	Size of Valve. Inches Diam.	Size of Runout Inches. Diam.
100	1½	1½	1½
70	1¼	1¼	1¼
40	1	1	1

Size of riser from Table I will be equivalent to ½ pipes for

1—1½ in. = 1 × 15.8 (½-in. pipes) = 15.8
1—1¼ in. = 1 × 10.0 (½-in. pipes) = 10.0
1—1 in. = 1 × 4.88 (½-in. pipes) = 4.88

30.68 (½-in. pipes)

30.68 (½-in. pipes) = 2 in. drop.
Six risers equal to 30.68 (½-in. pipes) each = 184.08
184.08 (½-in. pipes) = 4-in. main at boiler.

(*Concluded on Data Sheet No.* 133-J)

WATER HEATING—GRAVITY.

Sizing Mains and Risers for One-Pipe Systems.

(*Concluded from Data Sheet No. 133-I.*)

Drops and mains may also be sized by means of the use of factors, as given in the following table:

EQUIVALENT PIPE FACTORS.

Nominal Size of Pipe Inches Diam.	Factor
½	2
¾	5
1	10
1¼	20
1½	30
2	60
2½	110
3	175
3½	260
4	380
5	650
6	1050
7	1600
8	2250

Taking the same problem
1—1½ in. = 1 × 30 (factor) = 30
1—1¼ in. = 1 × 20 (factor) = 20
1—1 in. = 1 × 10 (factor) = 10
60 (factor) = 2 in. riser.
Six risers each with a factor of 60 =
6 × 60 (factor) = 360 (factor) = 4 in. main at boiler.
This checks with the sizes already found.

As a matter of fact, however, the circulation in the riser is governed by the *height* of riser, and the *temperature* of the water therein, and *not* by the *size* of the radiator runouts. Therefore, the radiators exercise no influence on the circulation in the riser excepting that they cool the water to produce the circulation. If these radiators were all situated, say, 80 ft. above the boiler, the riser could be sized from Table I on Data Sheet No. 133-G, from which it will be seen that 210 sq. ft. (total radiator surface) situated 80 ft. above the boiler level will require only a 1¼-in. riser, instead of a 2-in. as was indicated by the use of the radiator tappings. Owing to the top radiator having a 1½-in. connection the drop would probably be made 1½-in. anyway.

Now suppose the top radiator of 100 sq. ft. to be located 80 ft. above the boiler, the 70 sq. ft., as 20 ft. above the boiler and the 40 sq. ft. as 10 ft. above the boiler. In this case the circulation will be determined by the *average* temperature of the riser and this can easily be found by determining an equivalent elevation upon which all the radiation could be placed and produce the same effect.

The average distance that all the radiation is above the boiler is found by the formula

$$\frac{(a \times fa) + (b \times fb) + (c \times fc) + (d \times fd) \text{ etc.}}{a + b + c + d \text{ etc.}}$$

in which a, b, c, d, etc., are the square feet of radiator surface and fa, ba, ca, da, etc., are the respective vertical distances above the boiler in feet.

In the particular case in question

a = 100 sq. ft. af = 80 ft.
b = 70 sq. ft. bf = 20 ft.
c = 40 sq ft cf = 10 ft.

Substituting

$$\frac{(100 \times 80) + (70 \times 20) + (40 \times 10)}{100 + 70 + 40} =$$

$$\frac{8000 + 1400 + 400}{210} =$$

$\frac{9800}{210} = 46$ ft. equivalent distance of all radiation above boiler.

According to the same Table I (Data Sheet No. 133-G) this will require a 1½-in. riser.

WATER HEATING—GRAVITY.

Capacity of Risers.

Owing to the fact that radiators are often situated at intermediate points up the riser, it is self-evident that there will be a greater tendency to circulate to the upper radiators than to the lower, owing to the increased head due to the additional height, giving a greater velocity in the high risers. Where all the radiation is located at the top of the riser, and the riser is one size all the way, the problem is comparatively simple, but where radiators are fed at each and every floor, the lower radiators must be cared for in some manner to insure their receiving the proper circulation in spite of their lower elevation.

Assume six radiators of 100 sq. ft. each set one over the other on each floor of six stories, 10 ft. apart, and assume the vertical distance from top radiator to boiler to be about 65 ft. To size the supply pipe for such a condition refer to Table I (Data Sheet No. 133-G) and obtain the proper size of valve and branch supply for each radiator according to its elevation. The schedule is as follows if the factors given in Data Sheet No. 133-J are used to equate the pipe sizes:

Floor	Size, Sq. Ft.	Elevation Feet	Size of Valve, In. Diam.	Factor	Sum of Factors	Size of Riser, In. Diam.
Sixth	100	65	¾	5	5	¾
Fifth	100	55	1	10	15	1¼
Fourth	100	45	1	10	25	1½
Third	100	35	1	10	35	2
Second	100	25	1¼	20	55	2
First	100	15	1¼	20	75	2½
Base Boiler	0	none	—	—	—	—

This allows each radiator to be treated as a separate proposition and to be handled entirely on the basis of its size and elevation above the boiler, this treatment being carried back through the riser and the mains by means of the pipe equations used to size the risers and mains.

WATER HEATING—GRAVITY.

Two-Pipe Circuit System.

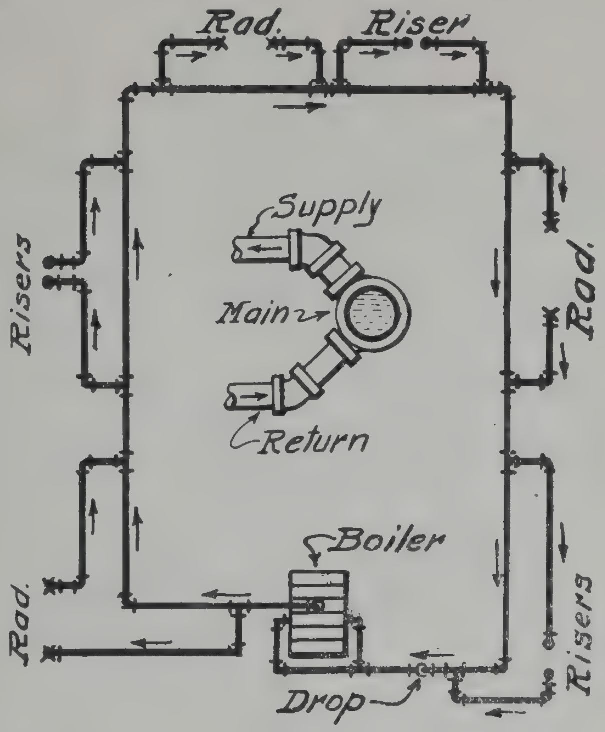


FIG. 1

Occasionally a water heating system is found employing a two-pipe up-feed riser system, with a single pipe circuit main at the bottom. The idea is somewhat similar to that employed in the one-pipe system described in Standard Data Sheet No. 133-C, but as the basement main is horizontal, the friction in the main is depended upon to assist the circulation into the supply riser. Fig. 1 illustrates a typical circuit main of this character, and it will be noted that the supply risers are always branched from the main at point as near the boiler inlet as possible. The return drop, however, is connected back into the same main at a point as far away from the supply connection as possible. The friction in the pipe existing between the branching of the supply and the connecting in of the return causes a slightly greater pressure to exist at the point of the supply branch than exists at the point of the return coming back into the main and the farther apart these connections are made the greater this difference in pressure will be and the greater will be the tendency to circulate the water through the radiators.

In the circuit main it is usually customary to size the main to carry the total load and to maintain this size undiminished throughout, although theoretically and practically it can be reduced between the supply and return connections, on account of some of the water being shunted through the radiators.

This main should be graded up from the boiler outlet to the last riser connection and then down to the boiler return inlet or may be carried to a high point directly over the boiler (this high point being vented by a supply branch being connected thereto) and then pitched down constantly and continuously from this high point to the return connection of the boiler.

With systems of small size a circuit main may give reasonable satisfaction, but where larger installations are contemplated some other scheme must be adopted if satisfactory operation is expected.

WATER HEATING—GRAVITY.

Expansion Tanks.

All water heating systems should have an expansion tank, the only exceptions being where systems are fed from a house tank or street main and are under direct pressure at all times without a valve in feed-water line so that this line can act as an expansion pipe, the water expanding back into the tank or main as the case may be. Such conditions exist in installations where radiators are connected to the hot water service supplying hot water to the plumbing fixtures.

The expansion tank should be large enough to contain all the excess water due to expansion plus about 50%. For ordinary small systems many manufacturers rate their expansion tanks in square feet of radiation, a typical list being given in Data Sheet No. 133-B.

For large systems the quantity of expansion should be calculated. This can be approximated by allowing one pint of water as contained in each square foot of radiator surface, add 25% for the water in the piping (or calculate the exact quantity in the piping if the system is designed and all lines sized) and add one pint for each square foot of heating surface in the boiler or boilers.

Example: Compute size of expansion tank for 14,000 sq. ft. of surface with two boilers, each rated at 10,000 sq. ft.

Solution:

14,000 sq. ft. @ 1 pint = 14,000 pints = 1750 gal.
25% for piping = 1,750/4 gal. = 437.5 gal.
Two 10,000 ft. boilers =

$$\frac{20{,}000 \times 150}{33{,}000} = \frac{1000}{11} = 90 \text{ H. P.}$$

90 × 10 sq. ft. = 900 sq. ft. and
900 × 1 pt. .... = 900/8 = 112.5 gal.

2300 gal.

Assuming system filled with water at 50° F. and that it may be heated to 220° gives a temperature rise of 220 — 50 = 170° for expansion of water. From tables giving the properties of water we find that, if the volume at 39.1° is taken as 1, at 50° the volume is increased to 1.00025 and at 212° to 1.04332, making the net increase in volume 1.04332 — 1.00025, or 0.04307 and 0.04307 ÷ 1.00025 = 4 3/10%, or say, 5%.

Then if the total volume is 2300 gal. the expansion in heating from 50° F. to 212° F. will be approximately 5% of 2300 or 115 gal. Adding 50% to obtain the expansion tank capacity gives

Expansion of Water...............	115 gal.
50% of 115........................	57 gal.
Total...........	172 gal.

This is at the rate of 172/14 or 12 gal. per 1000 sq. ft. of radiation.

WATER HEATING—GRAVITY.
Details.

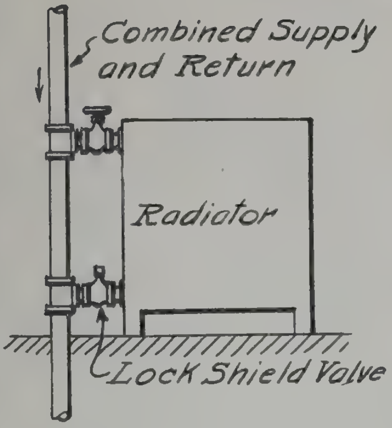


FIG. 1

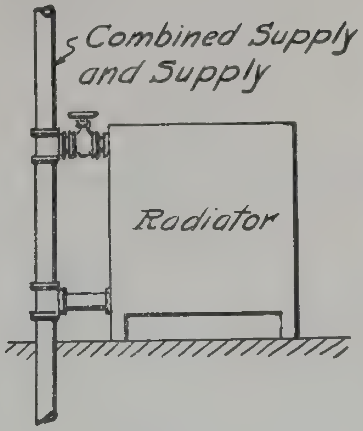


FIG. 2

In all one-pipe gravity water heating systems the radiator connections are practically the same; these connections are usually made top-and-bottom, same end as shown in Fig. 1; the valve should be a gate valve with a ⅛ in. hole drilled through the gate to prevent freezing.

In Fig. 2 the connections are shown with the addition of a control valve on the return to control the circulation through the radiator. The danger in such systems, however, consists of the liability of the radiator not getting enough water (due to the full size by-pass which the main drop provides) rather than a liability of the radiator getting too much.

Even with the mains and risers sized by the methods shown the tendency is for the hottest water to seek the top radiators making it necessary to use various expedients to control the flow and to induce a proper circulation in the lower radiators. Of course, all devices to control hot water circulation consist of introducing additional resistance in the lines at points where the circulation has become excessive and resulting in preventing other parts of the system having greater resistance (or less favored positions) getting a good circulation.

These methods of control may be divided into

(a) Special fittings
(b) Special pipe connections
(c) Special control valves.

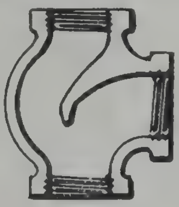


FIG. 3

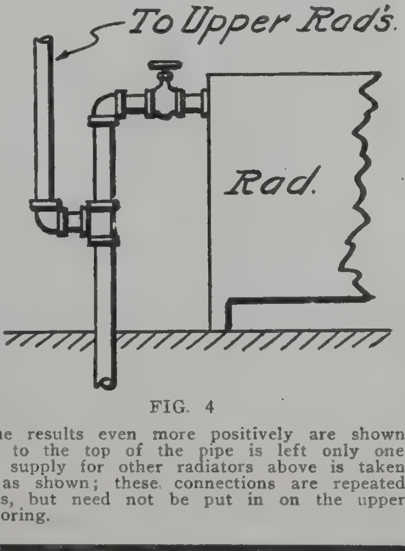


FIG. 4

A special fitting designed for just such conditions is shown in Fig. 3, the idea of this fitting being to induce a flow into the radiator at the level where the fitting is located in preference to flowing up the riser to the higher points.

Pipe connections to produce the same results even more positively are shown in Fig. 4 where the hot water in rising to the top of the pipe is left only one place to go (into the radiator) while the supply for other radiators above is taken from the side of the riser lower down as shown; these connections are repeated at each of the lower radiator connections, but need not be put in on the upper levels as these radiators do not need favoring.

WATER HEATING—GRAVITY

Details (Cont'd).

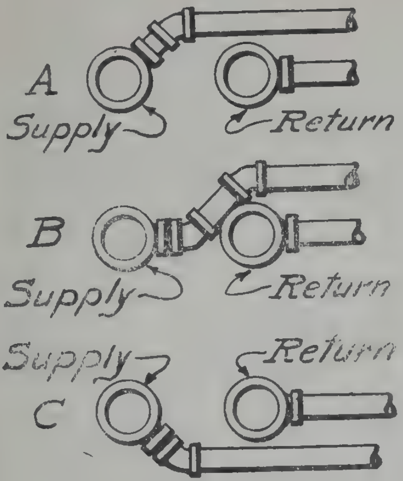


FIG. 5

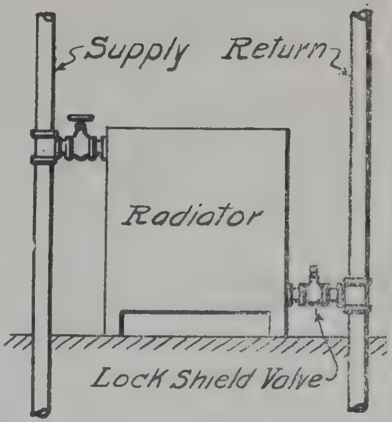


FIG. 6

Similar results are obtained in the horizontal mains where the risers are branched off as shown in A, B and C in Fig. 5, Detail C being used for about one-third of the risers nearest to the boiler (which would otherwise obtain the hottest water and the best circulation), Detail B being used for about one-third of the risers, these being located about midway between the boiler and the end of the main, and Detail A for the last third of the risers at the far end of the system.

Special control valves are by far the most satisfactory of all methods of controlling the circulation as they may be set in any graduated degree desired or left open entirely if the circulation is satisfactory. It is indeed a question (when the extra cost of special fittings or special pipe connections is considered) if the control valve is not very nearly as cheap as any other method of control—certainly its results are much superior. A gravity water heating system without control valves is much like a ventilating system without volume dampers.

If key-operated valves are placed on the return connection of each radiator, as shown in Fig. 6 and the rest of the piping is designed with proper pitch and so as to avoid air pockets no further precautions need be taken, for all that is necessary to do is to begin at the hottest radiators and gradually close the return valve until the resistance to the flow of water through them is sufficient to induce a circulation in the other radiators not receiving their full quota. After once adjusting the system in this manner the return valves can remain set permanently and the radiators controlled by the supply valves.

All radiator valves for hot water should have a ⅛-in. hole drilled in them so that the circulation in the radiator will never be entirely stopped even when the radiator is closed off. This will prevent damage by freezing under any ordinary conditions.

WATER HEATING

Figuring Friction Heads

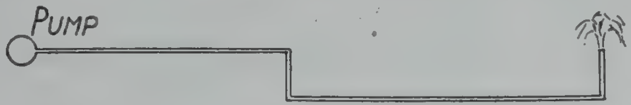
In the accompanying diagrams, which are based on tests made by Professor F. E. Giesecke, head of the Division of Engineering Research, University of Texas, and which allow for increase of friction due to age, the sloping lines represent the nominal diameter of the pipe in inches and the sloping dotted lines represent the velocity of the water in inches per second (not in feet, as might be supposed).

To understand the use of these charts, note from Data Sheet 133-Q that when 200 gal. per minute flow through a 6-in. pipe, the friction-head is 4/100 in. per foot of pipe and the velocity of the water between 24 in. and 36 in. per second; also that for 30 gal. and a 2½-in. pipe the friction-head is 1/10 in. per feet of pipe and the velocity slightly less than 24 in. per second.

From Data Sheet No. 133-R, when 200 gal. of water per minute are flowing through a 6-in. pipe, the velocity of the water is between 24 in. and 36 in. per second, and the friction-head is about 6/100 in. of water column for each elbow; also for 30 gal. and a 2½-in.-pipe, the friction-head is about 53/100 in. per elbow, and the velocity slightly less than 24 in. per second.

PRACTICAL APPLICATIONS

Example 1. What pressure-head must be maintained by the pump shown if 10 gal. per minute flow through a 1-in. pipe 142 ft. long and containing seven elbows?



We find from Data Sheet 133-Q that for 10 gal. per minute flowing through a 1-in. pipe, the velocity is practically 44 in. per second and the friction-head per foot of pipe is 1.05 in., and from Data Sheet 133-R that the friction-head per elbow is practically 2.8 in.

It should be noted here that the velocities shown in Data Sheet 133-R are not those in the elbow but those in the pipe which the elbow fits.

The total friction-head is, therefore,

142 x 1.05 = 149.2 for the pipe
7 x 2.8 = 19.6 for the elbow
Total 168.8 in. of water column.

The velocity head is $\frac{4 \times 4}{64.4} = 0.25$ feet or 3 in.

Therefore, the pump must maintain a pressure-head of 169+3=172 in., or 14.3 ft. of water column, or 6.2 lbs. per square inch: The water will be thrown about 3 in. into the air if it isdischarged from the open end of the 1-in. pipe.

ANOTHER EXAMPLE

Example 2. What pressure must be maintained by the pump in the system described in Example 1 if 12½ gal. of water flow through the pipe and if an open globe valve is added to the line?

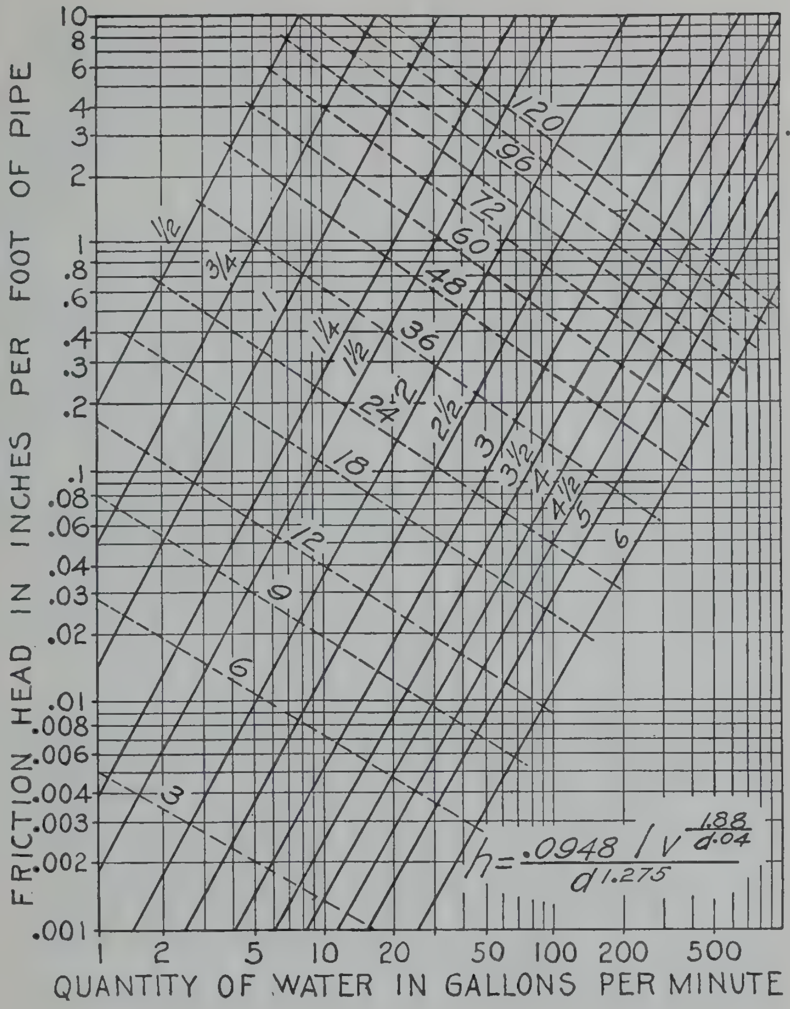
Note that the friction in an open globe valve is approximately equal to that in twelve elbows and proceed exactly as in Example 1. The velocity is about 4.5 ft. per second and, therefore, the velocity-head is 4 in. The friction-head is about 1.6 in. per foot of pipe and 4.3 in. per elbow. The total friction-head is 142 x 1.6 + 19 x 4.3 = 25.8 ft. and the total pressure-head is 26.1 ft.

(Continued on Data Sheet No. 133-Q)

WATER HEATING

Figuring Friction Heads

(*Continued from Data Sheet No. 133-P*)



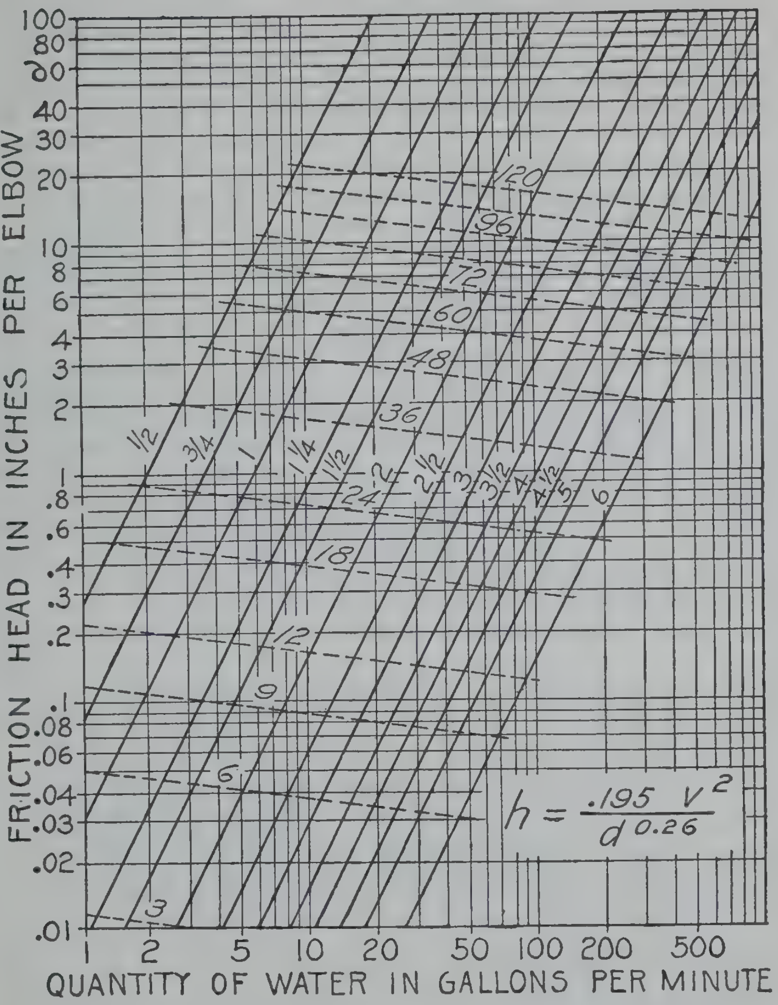
$$h=\frac{.0948\ l\ V^{\frac{1.88}{d^{.04}}}}{d^{1.275}}$$

(*Concluded on Data Sheet No. 133-R*)

WATER HEATING

Figuring Friction Heads

(Concluded from Data Sheet No. 133-R)



FANS.

Definitions.

Blower:—A centrifugal blower is a cased fan wheel having two inlets for the admission of air, one on either side and each concentric with the shaft.

Exhauster:—An exhauster is of much the same construction as a blower, but has only one inlet, and that usually in the side farthest from the pulley, engine, turbine or motor.

Overhung Wheel Fan:—An overhung wheel fan is one where the wheel is overhung upon the shaft; that is, where both of the bearings supporting the shaft are on one side of the wheel. This is usually arranged so that the pulley runs between the two bearings, and the shaft is extended through the fan casing to take the wheel. Exhausters are nearly always of the overhung wheel type, except in the larger sizes.

Overhung Pulley Fan:—An overhung pulley fan is one in which there is a bearing on either side of the fan wheel. The shaft being extended through one of the bearings to take the pulley, which is overhung upon it. Blowers and large exhausters are usually of the overhung pulley type.

Discharge:—The discharge of a blower or exhauster is designated by the direction in which the air is delivered from the casing; as for instance, bottom horizontal discharge or upblast discharge.

Hand:—The hand of a fan is that which designates upon which side of the casing the pulley or other driving apparatus is located, when one is facing the outlet of the fan. Some manufacturers designate a right-hand fan as one having the pulley, engine, turbine or motor on the right as one faces the outlet, and a left-hand fan is one having the pulley engine, turbine or motor on the left as one faces the outlet. An exception to the above occurs when the pulley, engine, turbine or motor is placed in the inlet of a single-inlet fan, in which case the housing itself may be left hand, and yet the pulley, engine, turbine or motor may be on the right. In such cases, which are very infrequent, and usually impracticable, full explanation should be given to avoid confusion.

With up or down angular discharge, also, the hand is determined by the location of the motor, turbine, pulley or engine, when the observer stands at the discarge end of the fan.

Other manufacturers determine the hand as follows: Standing on the driving side, looking parallel with the shaft, if the discharge is on the right-hand side of the shaft it is a right-hand fan, if on the left it is a left-hand fan.

This method has the advantage of avoiding any confusion, such as is possible by the first-named method, regardless of the angularity of the discharge, or whether it is up or down. Neither is there any confusion whether the motive power is on the inlet side or the opposite side of the fan.

Full Housing Fans:—A fan with full housing has a complete scroll or casing

Three-fourths and Seven-eighths Housing Fans:—When the lower portion of the scroll is dispensed with, and the fan is located upon a foundation which serves the purpose of a lower part of the casing, the fan is called three-fourths fan, in the steel plate type, and seven-eighths housing fan in the multiblade type

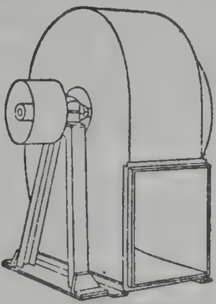
FANS

Hand and Discharge of Fans

Standard Types for Belt Drive—Overhung Pulley.

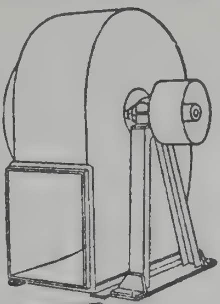
Bottom
Horizontal
Discharge

Left-Hand



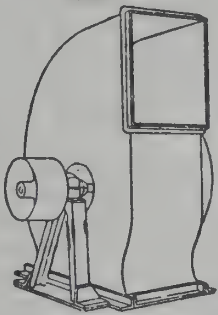
Bottom
Horizontal
Discharge

Right-Hand



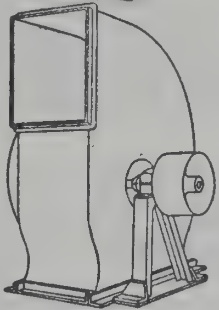
Top
Horizontal
Discharge

Left-Hand



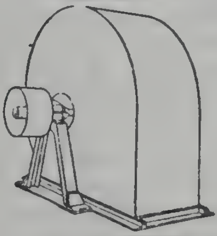
Top
Horizontal
Discharge

Right-Hand



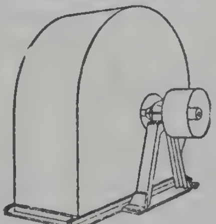
Down
Blast
Discharge

Left-Hand



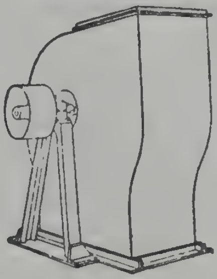
Down
Blast
Discharge

Right-Hand



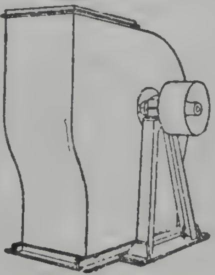
Up
Blast
Discharge

Left-Hand



Up
Blast
Discharge

Right-Hand



B. F. Sturtevant Co

BELTING.

In Europe cog-wheels are used to transmit power almost exclusively; but in America 99% of the power transmitted is by belting. Cog-wheel transmission is positive, belting is not, because with every revolution of a pulley a portion of the power is lost; the loss varies with the condition of the belt, change of load, state of the atmosphere, etc. The power of a belt to transmit motion is derived from the friction hold on the pulley; this is governed by the pressure or tension; a safe maximum working tension is about 45 lbs. per inch in width.

No dogmatic rule can be laid down to determine the efficiency of a belt. After a series of numerous experiments, Joshua Rose ("Modern Machine Shop Practice") states that belts vary from 25% to 100% in efficiency, for reasons given above.

A long belt will transmit more power than a short one, of same width and tension. Consequently long belts are always the best if it is possible to use them. A 1-in. belt traveling 800 ft. per minute and with proper tension will transmit 1 horse-power. If the same belt travels 1,600 ft., the power will be doubled. Each additional inch to the width will add 1 H. P., at the same speed and tension.

A belt under good conditions will deliver 97% of its efficiency. If the belts are too tight there will be quite a loss from friction of the journals, etc.; if too loose, there will be still more loss by slipping. Excessive slipping also dries out the leather and reduces the adhesion. Within reasonable limits the greater the speed the more efficient a belt will be. About 3,750 ft. per minute seems to be the maximum. A double belt will last longer than a single one, will take double the tension, and will transmit 1.7 times as much power, as capacity to transmit power is governed by the frictional width of belt and its pulling strength. Belts should be used with the hair side to the pulley. If pulleys are covered with leather, there will be a gain of 25% in wear of belt and in power transmitted.

It is best to have the belts run off from the main shaft in opposite directions to equalize the strain on the bearings. Let the diameter of the pulleys be as large as possible within the maximum belt speed (3,750 ft. per minute); a belt should never be overworked, and the tension such as will give a slight sag when in motion.

The per cent. of power lost by shaft journal friction should not exceed 20% of the full load; if it does it may be charged to tight belting. The breaking strength of good leather belting per inch in width in the solid leather, 675 lbs.; at rivet holes, 362 lbs.; at lacing holes, 200 lbs. It will be seen, therefore, that belts would be far more durable if lacing could be done away with, as is being done in some establishments, the ends of belts being lapped and cemented, thus making the joints as strong as the body of the belt.

BELTING.

To find the length of belt wanted: Rule 1. Add the diameter of both pulleys together, divide by 2, and multiply quotient by 3 1/8; add this product to twice the distance in inches between the center of shafts, and the final sum will be the length required. Example. Diameter of large pulley 24 in. + 12, (diameter of small pulley) = 36 ÷ 2 = 18 × 3 1/4 = 58 1/2 × 216 (twice distance between shafts) = 274 1/2 in. length required.

To find width of belt required for a given horse-power: Rule 2. Multiply the horse-power by the constant 2,750, then multiply the diameter of driven pulley by the number of revolutions and divide the first product by the latter. The quotient will be the width of belt required. Example 2. Horse-power 28 × constant 2,750 = 77,000; diameter of pulley 36-in. × revolutions 200 = 7,200; 77,000 ÷ 7,200 = 10 in., width required.

To find the horse-power which a belt will transmit. Rule 3. Multiply the width of belt by diameter of driven pulley in inches. Multiply this product by revolutions of pulley per minute, then divide final product by constant 2,750. The quotient will be the horse-power. Example 3. Belt 10 in. × 36 (diameter of pulley) = 360 × 200 revolutions = 72,000 ÷ 2,750 constant = 26.5 H. P. required.

The horse-power and width of belt given, to find the diameter of driven pulley required. Rule 4. Multiply the horse-power by constant 2,750, now multiply revolutions of pulley by the width of belt, then divide the first product by the latter. The quotient will be the diameter wanted. Example 4. Horse-power 28 × 2.750 = 77,000; revolutions 200 × 10 = 2,000; 77,000 ÷ 2,000 = 385 diameter wanted.

The horse-power, diameter of pulley and width of belt given, to find the number of revolutions of driven pulley. Rule 5. Multiply the horse-power by 2,750, now multiply the diameter of pulley by the width of belt, and then divide the first product by the latter. Example 5. Horse-power 28 × 2,750 = 77,000; diameter 36 × 10 width = 360; 77,000 ÷ 360 = 211.4 revolutions wanted.

BELTING.

Table of Belt Contacts.

						Constant.	
Degrees of Contact		Fraction of Contact		Decimal Fraction of Circumference	Ratio	Single Belt	Double Belt
90	or	1/4	=	0.25	2.21	6080	4250
112	or	5/16	=	.312	1.72	4730	3310
120	or	1/3	=	.333	1.6	4400	3080
135	or	3/8	=	.375	1.4	3850	2700
150	or	5/12	=	.417	1.24	3410	2390
165	or	7/16	=	.437	1.17	3220	2250
180	or	1/2	=	.500	1	2750	1925

For all practical purposes, the arc of contact of belt on smaller pulley can be roughly estimated by comparison with figures in first column in table above. For example, take the arc of contact 150° and compare it with your belt. If it agrees approximately, then taking Rule 3 we have Example 3 (Standard Data Sheet No. 168-B, modified as follows: Belt 10 × 36 = 360 × 200 = 72,000. By new constant 3,410 = 21.1 H. P., or a loss of 5.4 H. P. as compared with full contact or half circumference in Example 3.

To find length of belt when closely rolled. Add the diameter of the roll in inches to the diameter of the eye, multiply this by the number of turns. This result multiplied by the decimal, 0.1309 will give the length of roll in feet.

RULES FOR FINDING SPEED AND SIZE OF PULLEYS.

To find the size of driving pulley, multiply the diameter of driven by revolutions it should make, and divide the product by revolutions of driver.

Example 1: Diameter of driven pulley 12 in., revolutions, 240; revolutions of driver, 160; then $12 \times 240 = 2{,}880 \div 160 = 18$, diameter of driver wanted.

To find the size of driven pulley, multiply diameter of driver by its revolutions, and divide the product by revolutions of driven.

Example 2: Diameter of driver pulley, 18; revolutions, 160; revolutions of driven, 240, then $18 \times 160 = 2{,}880 \div 240 = 12$, diameter of driven wanted.

To find the number of revolutions of driven pulley, multiply diameter of driver by its revolutions, and divide product by diameter of driven.

Example 3: Diameter of driver pulley, 18 in.; revolutions, 160; diameter of driven, 12 in.; then, $18 \times 160 = 2{,}880 \div 12 = 240$, revolutions of driven wanted.

To find the horse-power of a driving pulley, multiply the circumference of pulley by the revolutions, and this product by width of belt, and divide final product by 600.

Example 4: Circumference of pulley, 56.55 in.; revolutions, 160; width of belt, 6 in.; then $56.55 \times 160 = 9048 \times 6 = 54{,}288 \div 600 = 9.04$, horse-power ot pulley wanted.

The above rules assume that the driving and driven pulleys are of equal diameter and the contact of belt half the circumference. If pulleys are of different diameter and contact of belt is less than half of circumference; then the rules must be modified as per tables of areas of contact (See Standard Data Sheet No. 168-C).

Weight of Round Galvanized Iron Pipe and Elbows

OF THE PROPER GAUCES FOR BLAST-PIPE SYSTEMS

Diameter of Pipe in Inches	Gauge of Iron	Weight per Running Foot in Pounds	Actual Weight of Full Elbow	Diameter of Pipe in Inches	Gauge of Iron	Weight per Running Foot in Pounds	Actual Weight of Full Elbow
3	25	0.9	0.6	38	18	23.7	179.8
4	25	1.3	1.1	39	18	24.3	189.4
5	25	1.6	1.6	40	18	24.9	199.2
6	25	1.9	2.3	41	16	31.5	258.4
7	25	2.1	3.0	42	16	32.2	270.7
8	25	2.4	3.9	43	16	32.9	283.3
9	25	2.7	4.9	44	16	33.7	296.2
10	25	3.0	6.0	45	16	34.5	310.3
11	24	3.7	8.2	46	16	35.2	323.8
12	24	4.1	9.8	47	16	35.9	337.6
13	24	4.4	11.4	48	16	36.7	352.6
14	24	4.7	13.2	49	16	37.4	367.0
15	24	5.0	15.1	50	16	38.2	381.6
16	24	5.4	17.1	51	16	39.0	397.6
17	22	6.9	23.5	52	16	39.7	412.8
18	22	7.3	26.3	53	16	40.5	430.5
19	22	7.7	29.3	54	16	41.4	447.5
20	22	8.2	32.8	55	16	42.3	464.8
21	22	8.5	35.9	56	16	43.0	481.3
22	22	8.9	39.3	57	16	43.8	499.2
23	20	11.0	50.7	58	16	44.5	516.2
24	20	11.5	55.1	59	16	45.3	533.6
25	20	12.0	59.9	60	16	46.0	552.5
26	20	12.4	64.3	61	14	57.5	701.5
27	20	12.9	69.9	62	14	58.4	724.2
28	20	13.4	75.2	63	14	59.3	747.2
29	20	13.9	80.6	64	14	60.3	771.8
30	20	14.4	86.3	65	14	61.2	795.6
31	20	14.9	92.4	66	14	62.2	821.4
32	18	20.0	127.4	67	14	63.0	844.2
33	18	20.6	135.8	68	14	64.0	870.4
34	18	21.2	144.2	69	14	65.0	897.0
35	18	21.8	152.7	70	14	66.0	924.0
36	18	22.4	161.5	71	14	67.0	951.4
37	18	23.0	170.5	72	14	67.9	977.5

The weights as given include the weight of rivets and solder, and due allowance has been made for laps and trimmings. The elbows have the internal radius equal to the diamter of the pipe. Rectangular pipes are usually made of the same gauge as round pipes of equivalent area.

Note—Square pipes will weigh about 27 per cent more than round pipes whose diameter is the same as the side of the square pipe. (From B. F. Sturtevant Co.)

FOR REDUCING THE WEIGHT OF GALVANIZED IRON PIPE OF ONE GAUGE TO THAT OF ANOTHER GAUGE

Gauge.	GAUGE AND WEIGHT IN POUNDS PER SQUARE FOOT.																
	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
	4.53	3.91	3.28	2.97	2.66	2.41	2.16	1.90	1.66	1.53	1.41	1.28	1.16	1.03	0.91	0.84	0.78
12	1.00	0.86	0.72	0.66	0.59	0.53	0.48	0.42	0.37	0.34	0.31	0.28	0.26	0.23	0.20	0.19	0.17
13	1.16	1.00	0.84	0.76	0.68	0.62	0.55	0.49	0.43	0.39	0.36	0.33	0.30	0.26	0.23	0.22	0.20
14	1.38	1.19	1.00	0.91	0.31	0.74	0.66	0.58	0.51	0.47	0.43	0.39	0.35	0.32	0.28	0.26	0.24
15	1.53	1.32	1.10	1.00	0.90	0.81	0.73	0.64	0.56	0.52	0.48	0.43	0.39	0.35	0.31	0.28	0.27
16	1.70	1.47	1.23	1.11	1.00	0.91	0.81	0.71	0.62	0.58	0.53	0.48	0.44	0.39	0.34	0.32	0.29
17	1.88	1.62	1.36	1.23	1.10	1.00	0.90	0.79	0.69	0.63	0.59	0.53	0.48	0.43	0.38	0.35	0.32
18	2.10	1.81	1.52	1.38	1.23	1.12	1.00	0.88	0.77	0.71	0.65	0.59	0.54	0.48	0.42	0.39	0.36
19	2.38	2.06	1.73	1.56	2.40	1.27	1.14	1.00	0.87	0.81	0.74	0.67	0.61	0.54	0.48	0.44	0.41
20	2.72	2.36	1.98	1.79	1.60	1.45	1.30	1.16	1.00	0.92	0.85	0.77	0.70	0.62	0.55	0.51	0.47
21	2.96	2.56	2.14	1.94	1.74	1.57	1.41	1.24	1.09	1.00	0.92	0.84	0.76	0.67	0.59	0.55	0.51
22	3.21	2.77	2.32	2.10	1.89	1.71	1.53	1.35	1.18	1.08	1.00	0.91	0.82	0.73	0.65	0.60	0.55
23	3.54	3.07	2.56	2.32	2.08	1.88	1.69	1.49	1.30	1.20	1.10	1.00	0.91	0.81	0.71	0.66	0.61
24	3.90	3.37	2.82	2.56	2.29	2.08	1.86	1.61	1.43	1.32	1.22	1.10	1.00	0.89	0.78	0.72	0.67
25	4.40	3.79	3.18	2.88	2.58	2.34	2.10	1.86	1.61	1.49	1.37	1.24	1.12	1.00	0.88	0.82	0.76
26	4.98	4.30	3.60	3.26	2.92	2.65	2.37	2.10	1.82	1.68	1.55	1.41	1.27	1.13	1.00	0.92	0.86
27	5.40	4.66	3.90	3.54	3.17	2.87	2.57	2.28	1.96	1.82	1.68	1.52	1.38	1.23	1.08	1.00	0.93
28	5.81	5.01	4.20	3.80	3.41	3.09	2.77	2.45	2.13	1.96	1.81	1.64	1.49	1.32	1.17	1.08	1.00

The table above serves for the estimation of weights of pipe of gauges other than those given on Standard Data Sheet No. 169-E Thus, suppose it is desired to find the weight of 28-in. pipe made of No. 16 gauge. From the 169-E table, pipe of this size made of No. 20 gauge weighs 13.4 lbs. per running foot. By the table above, the figure found at the junction of the column headed **16** and the line designated **20** is 1.60; therefore, the weight per foot of No. 16 gauge is 13.4 x 1.60 = 21.44 lbs.
(From B. F. Sturtevant Co.)

CHEMISTRY LABORATORIES.

One of the hardest places to ventilate is the chemistry laboratory and probably more money has been spent in unsuccessful efforts in this line than in any other one direction. In the first place, chemistry ventilation is a most important and essential item and in the second place the persons delving into its mysteries usually belong to a well-educated and more or less scientific class who know and appreciate the requirements of good ventilation. Chemistry ventilation may well be divided into two parts (a) the room itself and (b) the hoods or cases where the experiments are made. In the ordinary use of the room no unusual feature is encountered and its air supply for this purpose may be based on six to eight air changes or 30 cu. ft. per person.

To remove the fumes from the glass cases in which the experiments are sometimes made is a more difficult proposition. The case door may be up one inch, one foot or four feet; the fumes may be lighter than the air and rise rapidly or they may be heavier than air and roll over the front of the counter and out into the room past the experimenter.

Cases used for such work are ordinarily 24-in. wide, 24-in. deep and about 60-in. high; on the top of the case a 24-in. x 24-in. hood is placed, usually with a 3-in. diameter pipe through which the air is exhausted from the case. According to the manufacturers, the air should be exhausted "two or three times a minute" from such hoods which makes the quantity of air 40 to 60 c. f. m. per case. This is not enough and may well be doubled. Even then, unless a pipe is run down to the counter level, as shown in Fig. 1, to catch the heavy fumes the results will be less than desired.

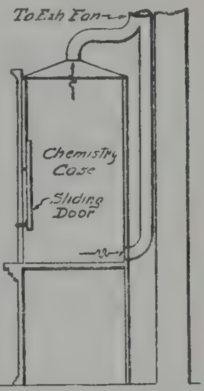


FIG. 1.

For the little individual hoods supported on goose necks for each pupil, these are exceedingly hard to do anything with owing to the large number usually installed where they are used. It is usual to allow 20 c. f. m. per hood and 1 1/8-in. static pressure for the exhaust fan. It is impossible to secure good results with the individual hood systems, due to the fact that the gases heavier than air are not caught.

No chemical exhaust should have steel or iron pipe owing to the corrosive action of the fumes; copper pipe is used with some success, but tile pipe is much better. The exhaust fan should have a cast-iron case painted with asphaltum and a monel metal impeller and shaft. The supply air should be increased until it is about 80% of the amount exhausted.

STEAM LAUNDRY EQUIPMENT.

General.

Steam laundry equipment is, to a great extent, special in design, and is built by manufacturers from their own patents and experience. In general features, however, steam laundries possess a considerable similarity of equipment to perform the necessary operations in order to properly wash, dry and iron the various articles of clothing which they are required to handle. All steam laundries employ steam to a considerable extent in their operations, hence the name—steam laundries—although this title does not necessarily mean that the power is supplied through a steam engine. In fact, a great many of the more modern laundries use motor-driven machines entirely.

The most important requisite in the design of a laundry is the obtaining of the number of pounds of steam required per hour for the operation of the equipment, the steam requirements usually consisting of the following: for running steam engine (if an engine is used), for drying (if a dry room is installed), for heating the mangles, for heating water and sometimes for warming various parts of the building, as well as for smaller connections to other apparatus.

If a building possesses a high-pressure boiler plant, no separate steam boiler is required for the laundry, but, on the other hand, if a building has only a low-pressure heating system, or for any other reason has no high-pressure steam, then a special steam boiler for laundry uses must be employed. In laundries where a steam engine is used to furnish power, it has generally been found that a steam drive is much more economical than an electric drive, owing to the fact that the exhaust from the engine may be utilized in the coils in the dryer, to heat the water, and also to provide steam for any radiation that may be desired. On the other hand, the space occupied by the engine, together with the belt, shafting, etc., may render the arrangement of the laundry less convenient than where individual motor drive is used.

Engine—If an engine is to be installed a moderate-priced slide-valve type is usually selected, this class of engine commonly requiring about 40 lbs. of steam per horsepower per hour, and, on an average, it is safe to figure that 85% of this steam is available in the exhaust for any low-pressure heating service which may be desired. Thus it can be seen that the installation of the engine would require an additional boiler horsepower of only some 15% of the engine steam consumption over what ordinarily would be required for heating if the engine were omitted. Thus for a 30 h. p. engine the increase in boiler horsepower would be 30 h. p × 40 lbs. × 15% ÷ 30 or about 6 boiler horsepower.

Where the exhaust from the engine is used to supply steam in the dryer and water heater, an oil separator should be placed in the line and the condensation should be returned to the boiler through a lift and direct-return trap or by means of an automatic return pump. If the calculations show that the engine exhaust is not sufficient to supply the dryer, hot water tank and any heating radiation which may be required, a pressure-reducing valve should be installed as a make-up from the high-pressure line.

Dryer Room—The steam required for drying is admitted to pipe coils located in the drying room or dryer and the number of square feet of the pipe in the coils times an efficiency of 350 B. T. U. per square foot will give the approximate B. T. U. supplied to the dryer, which amount divided by 250 will give the equivalent direct radiation (E. D. R.).

Mangle—The amount of steam required for the mangle is best obtained from the manufacturer, although a safe approximation is given in Table 4 on Standard Data Sheet No. 172-C. In order to perform the work satisfactorily it has been found that a steam pressure of approximately 60 lbs. gauge is required to give the proper degree of heat to the rolls.

STEAM LAUNDRIES.

Hot Water Supply.

The quantity of hot water required per hour is usually based on 1 gal. per hour for each piece daily capacity of laundry. Thus, a laundry designed to handle, say, 1,000 pieces per day should have a hot water supply of 1,000 gal. per hour. This quantity should be reduced to pounds by multiplying by 8⅓. The total B. T. U. per hour required will be the number of pounds of water times the temperature rise (which rise is usually assumed as 50° to 210° F., or 160° F.). The total number of B. T. U. divided by 250 will give the equivalent direct radiation. The tank capacity should be about 25% in excess of the demand to prevent excesive cooling of the water, by drawing off too great a proportion of the contents.

Multi-Coil Steam Heaters—The coil surface required to heat the amount of water necessary may be computed by finding the average temperature of the water passing through the heater $\frac{(210-50)}{2}$ or 130° for the temperatures which we have assumed, and the temperature difference between the average water temperature (130°) and the steam (220°) or 90°. With this temperature difference each square foot of coil surface will condense about 14 lbs. of steam per hour and the total coil surface will be the total amount of steam it is desirable to condense divided by 14; another safe ratio is to install a copper coil with 6 to 7 sq. ft. area for every 100 gal. to be heated per hour.

It is very desirable to have the hot water tank made of copper as iron tanks are liable to rust and discolor the clothes, while the heating coils should be of brass pipe and brass fittings; one head of the tank should be flanged and bolted so as to permit inspection and repairs.

Automatic temperature regulation should also be provided. These heaters are of stock design, and can be purchased from regular manufacturers, being known as the multi-tube or multi-coil heaters.

A few general dimensions for such heaters are given in Table 1.

TABLE 1. WATER STORAGE HEATERS.

Storage Capacity Gallons.	Heating Capacity Gals. Per Hr.	Diam. In.	Overall Length Inches.	Coil Surface Sq. Ft.
25	100	12	52	6½
50	200	15	66	13
75	300	18	76	19½
100	400	20	78	26
125	500	22	78	33
150	600	24	78	40
190	750	24	102	49
250	1000	30	84	67
375	1500	30	126	100
425	1750	36	102	117
500	2000	36	126	133
640	2500	36	150	167
700	3000	42	126	200
860	4000	42	150	286
1150	5000	42	198	333
1500	7500	48	198	500

Coal Heaters—In laundries where electric power is used for driving purposes, hot water is often heated by a cast-iron sectional heater, the size being based upon the burning of 5 lbs. of coal per hour per square foot of grate surface, and an efficiency of 8,000 B. T. U. per hour of coal burned. As it takes approximately 1,300 B. T. U. to heat one gallon of water from 50° to 210°, 1 sq. ft. of grate must be provided for approximately every 30 gal. of water per hour desired to be heated.

STEAM LAUNDRIES.

Boilers.

A large part of the heating in the laundry will be done by the radiation from the apparatus, dry room, etc., but it is usually also necessary to supply heat to supplement this to prevent the frezing of the pipes when the apparatus is not in operation and for adjoining rooms, offices, etc. Usually 250 B. T. U. per square foot for cast-iron radiators and 300 B. T. U. for pipe coils surface may be used for all such heating. The total B. T. U. divided by 250 gives the equivalent direct radiation to which 25% should be added for piping.

Boilers—The boilers generally used for laundry work are either of the vertical or horizontal return tubular type. The small vertical boilers are usually obtainabe in the sizes and horsepowers as shown in Table 2. While H. R. T. boilers are obtainable in almost any horsepower, a few of the standard sizes from 18 to 50 h. p. are given in Table 3; boilers should be of the high-pressure type designed for 100 lbs. workingpressure.

TABLE 2—VERTICAL BOILERS.

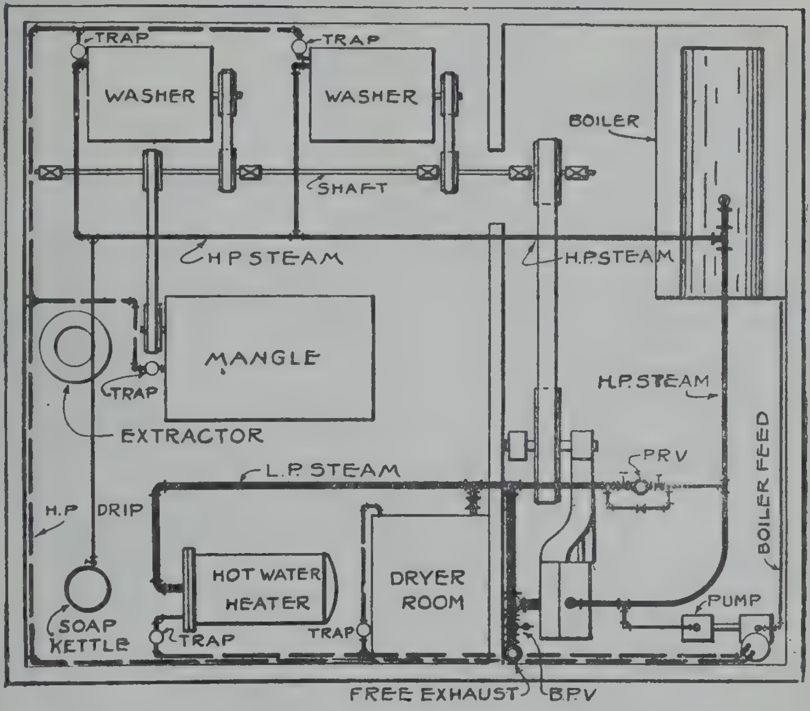
Diam of Shell In.	No. 2-in. Tubes.	Length Tubes.	H. P.
30	45	3 ft. 0 in.	5.8
30	45	3 ft. 6 in.	6.5
30	45	4 ft. 0 in.	7.3
30	45	4 ft. 6 in.	8.0
30	45	5 ft. 0 in.	8.7
36	65	4 ft. 0 in.	10.3
36	65	4 ft. 6 in.	11.4
36	65	5 ft. 0 in.	12.5
36	65	5 ft. 6 in.	13.5
36	65	6 ft. 0 in.	14.6
42	100	4 ft. 6 in.	17.0
42	100	5 ft. 0 in.	18.7
42	100	5 ft. 0 in.	18.7
42	100	5 ft. 6 in.	20.3
42	100	6 ft. 0 in.	22.0

TABLE 3—HORIZONTAL BOILERS.

Diamof Shell In.	No. 3-in. Tubes.	Lenghth Tubes.	H. P.
42	34	9 ft. 0 in.	18
42	34	10 ft. 0 in.	20
42	34	11 ft. 0 in.	22
42	34	12 ft. 0 in.	24
42	34	13 ft. 0 in.	26
42	34	14 ft. 0 in.	28
48	44	10 ft. 0 in.	30
48	44	11 ft. 0 in.	33
48	44	12 ft. 0 in.	36
48	44	13 ft. 0 in.	39
48	44	14 ft. 0 in.	42
48	44	15 ft. 0 in.	45
48	44	16 ft. 0 in.	48
54	54	11 ft. 0 in.	35
54	54	12 ft. 0 in.	38
54	54	16 ft. 0 in.	50
54	54	13 ft. 0 in.	41
54	54	14 ft. 0 in.	44
54	54	15 ft. 0 in.	47

STEAM LAUNDRIES.

Typical Arrangement.



A typical layout of a small steam laundry is shown in Fig. 1 in which the steam is generated in a high-pressure boiler and supplied to the engine and mangles at the boiler pressure. The low-pressure line is fed by the engine exhaust through an oil separator and is cross-connected to the high-pressure line with a pressure-reducing valve and by-pass. This exhaust line is also connected to the atmosphere through an atmospheric exhaust and back-pressure valve. The high-pressure returns are trapped and discharged back to the feed pump, and the low-pressure returns are separately trapped and also discharged to the same feed-pump upon which is mounted a vented receiver.

STEAM LAUNDRIES.

Data for Laundry Apparatus.

In the absence of definite information from the manufacturer of the special laundry machinery to be installed, the following information may be used as covering the average requirements likely to be encountered:

TABLE IV.

APPARATUS.	Boiler Horse Power (Approximate).	Steam Connections In. Diameter.			Water Connections In. Diameter.			Gas Connections In. Diameter.	Air Connections, In. Diameter.	Horse Power to Drive Mechanical.
Apparatus		Supply	Drip	Trap	Hot	Cold	Waste			
Washer (24 in.x24 in. and Vp.)	0.20	1/2	—	—	1 1/4	1 1/4	2 1/2	—	—	1
Washer (single geared) (33 in. x36 in. and Vp.)	0.20	1/2	—	—	1 1/2	1 1/2	3	—	—	1 1/2
Washer (double geared) (36 in.x54 in. and Vp.)	0.40	1/2	—	—	2	2	3	—	—	—
Washer (sterilizing)	0.20	1/2	—	—	1 1/2	1 1/2	3	—	—	—
Sterilizer	—	1	—	—						—
Skirt ironing table	—	—	—	—	—	—	—	3/8	3/8	—
Shirt ironing table	—	—	—	—	—	—	—	3/8	3/8	—
Ironer (sleeve)	—	1/2	1/2		—	—	—	3/8	3/8	0.3
Ironer (body)	—	1/2	1/2	—	—	—	—	3/8	3/8	0.3
Ironer. flat work (single roll)	1/2	1/2	1/2	1/2	—	—	—	—	—	—
Ironer, flat work, (three and five-roll)	3/4	1	3/4	1/2	—	—	—	—	—	—
Ironer, flat work, (100 in. five-roll)	1	1 1/4	1	3/4	—	—	—	—	—	1 1/2
Ironer, collar and cuff	1 1/2	3/4	1/2	3/4	—	—	—	—	—	1
Art edger			—	—	—	—	—	—	—	0.3
Cabinet dry room				(See description)						
Conveyor dry room, (two-loop)	4	1 1/4	1 1/4	1 1/2	—	—	—	—	—	0.75
Conveyor dry room, (three-loop)	5	1 1/4	1 1/4	1 1/2	—	—	—	—	—	1
Starcher, (collar and cuff)	0.2	3/8	3/8	—	—	—	—	—	—	.25
Dampener, (collar and cuff)	—	—	—	—	—	3/8	—	—	—	0.3
Dampener (wing point)	0.1	3/8	3/8	—	—	—	—	—	—	—
Dampener (skinner)	0.1	—	—	—	—	—	—	—	—	—
Dampener (spray)	0.1	3/8	—	—	—	3/8	3/8	—	—	—
Tumbler	6	1 1/4	1	—	—	—	—	—	—	3
Wash tube (each compartment)	0.05	—	—	1/2	1/2	1 1/2	—	—	—	—
Extractor	—	—	—	—	—	—	2	—	—	2
Soap tank	0.1	1/2	—	—	—	3/4	—	—	—	—
Bleach tank	0.1	1/2	—	—	—	1/2	—	—	—	—
Shaper (hot tube)	0.2	2/8	3/8	—	—	—	—	—	—	—
Shaper (collar)	—	—	—	—	—	—	—	1/4	—	—
Moulder (collar)	0.2	3/8	3/8	—	—	—	—	—	—	—
Press (bosom)	1	1	3/4	1/2	—	—	—	—	—	0.5
Press (dampening)	0.2	—	—	—	—	—	—	—	—	—
Press (neckband)	0.3	3/8	3/8	—	—	—	—	—	3/8	—
Press (cuff)	0.3	3/8	3/8	—	—	—	—	—	3/8	—
Press (yoke)	0.3	3/8	3/8	—	—	—	—	—	3/8	—
Starch cooker	0.1	3/8	3/8	—	—	3/8	3/8	—	—	—
Hot-water tank	—	—	—	—	—	—	—	—	—	—
Coal heater	—	—	—	—	—	—	—	—	—	—

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